Calendar No. 837

100TH CONGRESS *2d Session*	SENATE	REPORT 100-429

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AUTHORIZATION ACT, 1989

Mr. HOLLINGS, from the Committee on Commerce, Science, and Transportation, submitted the following

REPORT

OF THE

SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ON

S. 2209

JULY 26, 1988.—Ordered to be printed

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Mr. HOLLINGS, from the Committee on Commerce, Science, and Transportation, submitted the following

REPORT

[To accompany S. 2209]

The Committee on Commerce, Science, and Transportation, to which was referred the bill (S. 2209) to authorize appropriations to the National Aeronautics and Space Administration for research and development, space flight, control and data communications, construction of facilities, and research and program management, and for other purposes, having considered the same, reports favorably thereon with an amendment in the nature of a substitute and recommends that the bill do pass.

PURPOSE OF THE BILL

The purpose of the bill is to authorize appropriations to the National Aeronautics and Space Administration (NASA) totaling $11,104,500,000 for fiscal year (FY) 1987, as follows:

—	Budget request	Committee authorization
FY 1989:		
Research and development	$4,446,700,000	$4,278,200,000
Space flight, control, and data communications	4,841,200,000	4,686,200,000
Construction of facilities	285,100,000	260,100,000
Research and program management	1,915,000,000	1,880,000,000

LEGISLATIVE HISTORY

On March 2, 1988, the administration submitted its FY 1989 budget request for NASA. The Committee considered budget and related policy matters in hearings on February 16, March 7, 10, 22, and May 17. The Committee received testimony from the NASA Administrator and NASA officials associated with the major agency programs, the Director of the Office of Commercial Space Transportation in the Department of Transportation (DOT), and from the space science, space transportation, aeronautics, and educational communities.

On March 23, 1988, Senators Riegle, Hollings, Danforth and Pressler introduced by request, S. 2209, a bill to authorize appropriations for NASA for FY 1989.

On April 4, 1988, the Administration submitted its FY 1989 and 1990 budget request for DOT's Office of Commercial Space Transportation.

On May 24, 1988, the Committee met in executive session and considered the budgets for NASA and the Office of Commercial Space Transportation. S. 2209, the FY 1989 NASA Authorization bill, was ordered reported without objection by the Committee in open executive session with an amendment in the nature of a substitute. The amendment included language authorizing appropriations for FY 1989 for DOT's Office of Commercial Space Transportation.

NASA AUTHORIZATION SUMMARY

[In millions of dollars]

	FY 1989 request	Proposed FY 1989 Senate authorization
I. Research and Development	4,446.7	4,278.2
1. Space Station	967.4	867.4
2. Space Transportation Capability Development	631.1	606.6
Spacelab	80.4	
Upper Stages	146.2	153.2
Engineering & Tech. Base	158.9	
Payload Ops & Sup. Equip	67.3	
Advanced Programs	45.0	
Advanced Launch Systems	13.0	6.5
Tethered Satellite System	23.8	
Orbital Maneuvering Vehicle	96.5	
3. Space Science	1,297.3	1,252.3
A. Physics & Astronomy	791.6	761.6
Hubble Space Telescope Dev	102.2	
Gamma Ray Observatory Dev	41.9	
Global Geospace Science	101.4	76.4
Advanced X-Ray Astrophysics Fac	27.0	
Payload & Instrument Dev	77.1	
Shuttle-Spacelab Payload Mgt	61.5	
Sp. Station Integrated Planning and Attached Payloads	8.0	
Explorer Development	82.1	
Mission Operation & Data Analysis	156.2	
Research and Analysis	89.1	
Suborbital Program	45.1	
B. Life Sciences	101.7	91.7
C. Planetary Exploration	404.0	399.0
Galileo Development	61.3	
Magellan	33.9	

NASA AUTHORIZATION SUMMARY—Continued

[In millions of dollars]

	FY 1989 request	Proposed FY 1989 Senate authorization
Ulysses	10.3	
Mars Observer	102.2	
Mission Ops & Data Analysis	112.y	
Research and Analysis	83.6	
4. Space Applications	562.3	628.3
A. Solid Earth Observations	82.1	
Shuttle/Spacelab Payloads	25.3	
Geodynamics	33.9	
Research and Analysis	22.9	
B. Environmental Observations	368.3	
Applied Research, Data Analysis and Related Activities	108.1	
Payload & Instrument Dev.	19.7	
Scatterometer	15.8	
Upper Atmos. Res. Satellite (UARS)	103.9	
Ocean Topography Experiment (TOPEX)	97.8	
Airborne Science & Applications	23.0	
C. Materials Processing in Space	73.4	
D. Communications	16.2	92.2
E. Information Systems	22.3	
5. Commercial Programs	57.9	57.9
Technology Utilization	19.1	
Commercial Use of Space	38.8	
6. Aeronautical Research and Technology	414.2	404.2
Research & Technology Base	314.2	
Systems Technology Programs	100.0	
7. Transatmospheric Research and Technology	84.4	69.4
8. Space Research and Technology	390.9	350.9
9. Safety Reliability are Quality Assurance	22.4	22.4
10. Tracking and Data Advanced Systems	18.8	18.8
II. Space Flight Control and Data Communications	4,841.2	4,686.2
1. Space Shuttle Productions/Operations Capability	1,400.5	1.335.5
Orbiter Operational Capability	320.0	280.0
Launch & Mission Support	343.7	
Propulsion Systems	711.8	
Charges & Systems Upgrading	25.0	0
2. Space Transportation Operations	2,405.4	2,365.4
Flight Operations	660.1	
Flight Hardware	1,035.2	
Launch & Landing Operations	514.6	
Expendable Launch Vehicles	195.5	155.5
3. Space Tracking & Data Acquisiton	1,035.3	985.3
Space Network	538.9	
Ground Network	248.1	
Communications & Data Systems	248.3	
III. Construction of Facilities	285.1	260.1
IV Research and Programs Management	1,915.0	1,880.0
Total NASA	11,488.0	11,104.5

SUMMARY OF MAJOR PROVISIONS

For FY 1989, the Committee would authorize $11,104,500,000 for NASA and $3,827,000 for the office of Commercial Space Transportation. Of the amount authorized for NASA, $4,278,200,000 is authorized for research and development, including $8,000,000 to implement the National Space Grant College and Fellowship Program, and $4,686,200,000 for Space Flight Control and Data Communications. In addition, $260,100,000 is authorized for Construction of Facilities, and $1,880,000,000 for Research and Program Management.

The Committee provides $867,400,000 for the space station program. This is $100,000,000 below the President's FY 1989 budget request, but will be sufficient to begin actual construction of the hardware elements of the space station in earnest. The Committee continues to support strongly the space station program and reduced the FY 1989 request as a means to distribute necessary budget reductions in an equitable fashion.

The Space Transportation Capability Development budget of $606,600,000 is $24,500,000 below the President's FY 1989 budget request. Nevertheless, this level of funding will fully support the Orbiting Maneuvering Vehicle, preliminary activities for the Extended Duration Orbiter (EDO) definition activities for the Crew Emergency Escape Vehicle (CERV), and Spacelab activities. The proposed $7 million augmentation for upper stages will permit NASA to continue procurement of an upper stage for the Advanced Communications Technology Satellite (ACTS) which is scheduled for launch in 1922.

The Committee authorizes $1,252,300,000 for Space Science activities—Physics and Astronomy, Life Sciences and Planetary Exploration—which is a $242,800,000 increase over the FY 1988 NASA operating plan. The $761,600,000 provided by the committee for Physics and Astronomy will allow continued development of the Hubble Space Telescope, scheduled for deployment in November 1989, as well as continued funding for the Gamma Ray Observatory, scheduled for launch in March, 1990. Although the committee continues to support the Global Geospace Science effort, it recommends a rephasing of the program to obtain $25,000,000 savings in FY 1989.

Of major interest to the Committee in the Physics and Astronomy account are the initiation of a new start for the development of the next great observatory, the Advanced X-Ray Astrophysics Facility (AXAF), the continued expansion of the explorer Development program, and a continuing emphasis on the Suborbital flight program, all of which are provide for in this authorization.

The Committee has provided $399,000,000 for the Planetary Exploration program. This level of funding will support the launch of the Magellan satellite to Venus in April, 1989, the launch of the Galileo mission to Jupiter in November, 1989, and activities leading to the launch of the Ulysses mission in October, 1990. It will also support the continued development of the Mars Observer, which is scheduled for launch in 1992.

The Committee authorizes $91,700,000 for the Life Sciences programs, which is $10,000,000 below the President's FY 1989 budget request, but a significant increase over the FY 1988 operating plan.

The Committee authorizes $628,300,000 for Space Applications programs, which is $66,000,000 above the President's request. This increase consists of a general reduction in programs of $10,000,000, and a $76,000,000 increase for the Advanced Communications Technology Satellite (ACTS) which is scheduled for launch in 1992. The Committee authorizes $73,400,000 in FY 1989 for Materials Processing in Space activities including the continued development of flight hardware. Other programs and activities, such as Solid Earth Observations, the Upper Atmosphere Research Satellite (UARS), Scatterometer, and the Ocean Topography Experiment (TOPEX) satellite are supported strongly by the Committee.

The Committee authorizes $57,900,000 for NASA commercial programs, which is consistent with the President's request.

In Aeronautical Research and Technology, the Committee has authorized $404,200,000 which is $10,000,000 below the administration's FY 1989 request. This is, however, $69,400,000 above the FY 1988 operating plan, and reflects the Committee's view of the importance of these activities to the nation's economic health. Transatmospheric Research and Technology is authorized at $69,400,000 which is $15,000,000 below the President's FY 1989 budget request. Despite this reduction, the Committee continues to support this focused technology development program with NASA participation.

The Committee has made a $40,000,000 reduction in the proposed Pathfinder program, which is a new start candidate within the Space Research and Technology programs. Thus the Committee provides $350,900,000 for these activities, as opposed to the request of $390,900,000. This will, however, provide full funding for the Civilian Space Technology Initiative (CSTI), and $8,000,000 for implementation of the Space Grant Colleges and Fellowship program pursuant to an agreement with Dr. Fletcher. Another program of importance in this area, strongly endorsed by the Committee, is the Engineering Research Center program. This program is fully funded at $16,300,000, and will continue support to the nine universities selected in FY 1988, as well as establishing additional centers in FY 1989. The aim of this program is to expand the Nation's space technology base by using the vast resource base of the Nation's universities.

In recognition of the importance of safety and reliability to the entire civil space program, the Committee authorizes $22,400,000 for the Safety, Reliability and Quality Assurance program. This level of funding is the same as the administration's FY 1989 budget request and is $6,300,000 higher than the FY 1988 operating plan. The Committee also authorizes $18,800,000 for Tracking and Data Advanced Systems programs, which is identical to the President's request.

The total Research and Development budget for FY 1988 is $4,278,200,000, compared with a budget request of $4,446,700,000 and an FY operating plan of $3,294,500,000.

For Space Flight, Control and Data Communications for FY 1989, the Committee authorizes $4,686,200,000, compared to the President's budget request of $4,841,200,000 and an FY 1988 operating plan of $3,810,700,000. Of this amount, $1,335,500,000 is for Space Shuttle Productions and Operations Capability, $2,365,400,000 is for Space Transportation Operations, and $985,300,000 is for Space Tracking and Data Acquisition.

In formulating the Space Flight budget, the Committee felt strongly that no reductions could be made in any accounts which would affect the operations of the space shuttle, the proposed test program, or any anomaly resolution activities. Return of a safe, reliable space shuttle to flight status continues to be one of the highest priorities within the space program.

The President requested $1,400,500,000 for Space Shuttle Productions and Operations Capability in FY 1989. The Committee has reduced this request by $65,000,000—$40,000,000 in the structural spares program, and $25,000,000 in systems changes and upgrading—for a total authorization of $1,335,500,000. Despite these reductions, this account is still $247,200,000 above the FY 1988 operating plan.

The Committee authorizes $2,365,400,000 for Space Transportation Operations, which is $40,000,000 below the President's FY 1989 budget request. The entire $40,000,000 reduction will be applied to the expendable launch vehicle account. It represents a reduction of $15,000,000 for purchase of a second Titan III vehicle and a general reduction of $25,000,000. Despite these actions, the Committee continues to hold the position that it is essential for NASA to maintain a mixed fleet of launch vehicles. The Committee, therefore, provides $155,500,000 for the acquisition of expendable launch vehicles, an increase of $130,000,000 over the current operating plan, despite the severe budgetary constraints.

The Committee authorizes $985,300,000 for Space Tracking and Data Acquisition, which is $50,000,000 below the President's request. The Committee directs NASA to apply these general reductions in the most efficient manner without jeopardizing the integrity of the overall program. NASA must determine the relative costs and benefits of programs such as the Second Tracking Data Relay Satellite (TDRS) ground station and a replacement TDRS satellite.

In FY 1989, the Committee authorizes $260,100,000 for the Construction of Facilities programs. This is a $25,000,000 reduction from the FY 1989 budget request of the President. These reductions would occur at the Kennedy Space Center Space Station Processing Facility and in other general areas. The Committee continues to follow closely the wind tunnel modernization and rehabilitation program that was begun last year, and fully authorizes the requested amounts in FY 1989.

Funding in the Research and Program Management account is authorized at $1,880,000,000 in FY 1989, which is a general reduction of $35,000,000 from the budget request. The Committee expects, however, that NASA will still increase its civil service employee base by 525 positions in FY 1989.

The total authorization for NASA in FY 1989 is $11,104,500,000, compared with $11,488,000,000 requested by the President, and $9,026,500,000 in the FY 1988 operating plan.

The Committee has also included $3,870,000 in the reported bill for the operations of DOT's Office of Commerical Space Transportation.

I. RESEARCH AND DEVELOPMENT—$4,278,200,000

The Committee authorizes $4,278,200,000 for research and development activities in FY 1989. This is $168,500,000 less than the President's FY 1989 request.

The objectives of the NASA program of research and development are to extend our knowledge of the Earth, its space environment, and the universe; to expand the technology for practical applications of space technology; to develop and improve manned and unmanned space vehicles; and to assure continued development of the long-term aeronautics and space research and technology necessary to accomplish national goals. These objectives are achieved through the following elements:

Space Station.—A program to develop a U.S. space station to continue the Nation's leadership in space and to provide for enhancement of science and applications programs and to further the commercial utilization of space while stimulating advanced technologies.

Space Transportation Capability Development.—A program to provide for the development and use of capabilities related to the Space Shuttle. The principal areas of activity in Space Transportation Capability Development are efforts related to the development and flight certification of the jointly developed United States Italian Tethered Satellite System, development of the Orbital Maneuvering Vehicle, development and operations of the Spacelab systems, the development and procurement of upper stages that place satellites in high altitude orbits, the engineering and technical base support at NASA centers, payload operations and support equipment, and advanced programs study and evaluation efforts.

Space Science and Applications.—A program using space systems, supported by ground-based and airborne observations, (1) to conduct a broad spectrum of scientific investigations to advance our knowledge of the Earth and its space environment, the Sun, the planets, interplanetary and interstellar space, the stars of our galaxy and the universe; and (2) to identify and develop the technology for the useful applications of space techniques in the areas of advanced communications satellite systems technology; materials processing research and experimentation; and remote sensing to acquire information which will assist in the solution of Earth resources and environmental problems.

Technology Utilization.—The program includes activities to accelerate the dissemination to both the public and the private sectors of advances in NASA's research, technology, and development program.

Commercial Use of Space.—A program to increase private sector awareness of space opportunities and encourage increased industry investment and participation in high technology, space-based research and development.

Aeronautics and Space Technology.—A program to conduct the fundamental long-term research and to develop the discipline and systems technology required to maintain U.S. leadership in aeronautics and space.

Tracking and Data Advanced System.—This program includes activities to perform studies and provide for the development of systems and techniques leading to improved tracking and data program capabilities.

RESEARCH AND DEVELOPMENT BUDGET SUMMARY

[In millions of dollars]

	Proposed FY 1989 Senate authorization
I. Research and Development	(4,278.2)
1. Space Station	867.4
2. Space Transportation Capability Development	606.6
3. Space Science	1,252.3
A. Physics and Astronomy	(761.6)
B. Life Sciences	(91.7)
C. Planetary Exploration	(399.0)
4. Space Applications	628.3
A. Solid Earth Observations	(82.1)
B. Environmental Observations	(368.3)
C. Materials Processing in Space	(73.4)
D. Communications	(92.2)
E. Information Systems	(22.3)
5. Commercial Programs	57.9
6. Aeronautical Research and Technology	404.2
7. Transatmospheric Research and Technology	69.4
8. Space Research and Technology	350.9
9. Safety, Reliability and Quality Assurance	22.4
10. Tracking and Data Advanced Systems	18.8

1. SPACE STATION—$867,400,000

The Committee authorizes $867,400,000 for FY 1989 for the Space Station program. This is $100 million less than the President's request.

Summary of FY 1989 funding levels

Development	$935,400,000
Pressurized Modules	(188,000,000)
Assembly Hardware/Subsystems	(288,000,000)
Platforms and Servicing	(56,000,000)
Power System	(154,000,000)
Operations Capability/Utilization	(80,000,000)
Management and Integration	(169,400,000)
Flight Telerobotic System	20,000,000
Transition Definition	12,000,000
Total Space Station	[1] $867,400,000

[1] Reflects general reduction of $100 million.

Development of the U.S. permanently manned Space Station, as directed by President Reagan, will add new momentum to the civil space program and is essential to realizing the national goal of U.S. leadership in space. The Space Station program gives us our first opportunity to gain direct experience in long-term human operations in space and knowledge essential to future space exploration. The Station will uniquely enhance the U.S. Space Science programs, further the commercial utilization of space, and stimulate the development and application of advanced technologies of national importance. It is also an evenue of cooperation with our allies, demonstrating the peaceful uses of space for the benefit of all.

The Space Station will be unique because it will provide the United States with a permanently manned presence in space. It will be versatile because it capabilities will be remarkably diverse. This diversity is reflected in the Station's design, which features pressurized laboratories, accommodations for attached payloads, and free-flyiung unmanned platforms. This new national laboratory, a research center in space, will stimulate new technologies, enhance industrial competitiveness, further commercial space enterprises, and add greatly to our storehouse of scientific knowledge. Perhaps the most significant feature of the Space Station, essential to its utility for science, commerce, and technology, is the continuing presence of its crews. Men and women will be aboard the Station base full time. The potential of humans—with their creativity, their dexterity, their ability to perceive, to interact with instruments, and to respond to the unexpected—is unique and essential. The Space Station will be designed to exploit these human capabilities. The Space Station's microgravity environment, high levels of power, and extended time in orbit, will enable scientists to make new discoveries in materials research and life sciences. The Space Station's substantive research capabilities include far more than its pressurized volume. Its free-flying platforms will enable truly synergistic studies of the Earth's atmosphere, land masses, and oceans—referred to as Each system science. Moreover, the Station's external structure is designed to be a stable platform that will be available for mounting a number of specialized instruments and telescopes. Scientific instruments, whether in a laboratory or on a boom, required maintenance, upgrading, repair and replacement. The Station will accommodate these servicing functions. The Space Station will be designed to evolve, to be capable of growth in its capabilities, so that future needs and challenges can be met.

The U.S. Space Station will be a multi-purpose, international facility. In 1984, President Reagan invited the full participation of other nations. During the ensuing definition phase, Canada, member states of the European Space Agency (ESA), and Japan worked closely with the United States to define their participation. These parallel definition and preliminary design studies have resulted in the identification of the Space Station elements they are considering for development. Negotiations with these international partners for the development phase of the program are in their final stages. Negotiators from NASA and the Canadian Ministry of State for Science and Technology reached agreement in December 1987 on the text of a memorandum of understanding for the Canadian cooperation, whereby Canada will provide a mobile servicing system for use on the Station. On April 21, 1988, the federal government of Canada approved this agreement and Canada's contribution of $1.185 billion to the Space station program.

In March 1988, NASA and ESA reached agreement on another proposed memorandum of understanding. ESA will provide a pressurized laboratory module, an unmanned polar platform, and a coorbiting man-tended free flyer. A preliminary agreement also has been reached with Japan on their participation in the Space Station program.

The basic configuration of the Space Station and the supporting elements has been arrived at as a result of a lengthy and iterative three-year process involving NASA centers, U.S. industry, our international partners, and the national and international science communities. A detailed assessment of the Space Station program was also conducted by the National Research Council (NRC) Committee on Space Station. During this definition period, the design evolved in response to user requirements, developments of advanced technology, trade studies and cost assessments. The evaluation of the various Space Station options led to the selection of a baseline configuration, commonly known as the "dual keel" configuration. The launch of the first element of this configuration was planned for January 1994. Since this estimate represented a considerable cost increase over the target cost estimate made in 1983-84, the reasons for the increase were closely examined.

Following intensive review during early 1987, a phased approach for development of the Space Station was adopted. A "Revised Baseline Configuration" which includes major elements of the dual keel configuration was selected, with a commensurate reduction in design and development costs. As a result of necessary fiscal restraint during the FY 1988-90 period, the planned launch date for the first element launch was adjusted to March 1994. However, this schedule was recently revised as the result of a review conducted by NASA after a significant reduction of Space Station funding in the FY 1988 Continuing Resolution. Currently, the first elements of the Space Station program are scheduled for launch in 1995. However, the 1995 launch date is dependent upon Congressional approval of a three-year budget request for the Space Station program of $6 billion.

The revised baseline for the Space Station is comprised of a single horizontal boom structure with 75 KW of photovoltaic power, the U.S. laboratory and habitability modules and two international laboratory modules (one European and one Japanese), and a Canadian mobile servicing capability. These elements comprise the manned base and provide both internal and external accommodations for attached science and applications payloads. There are also two science and applications platforms, one U.S. and one European, to be launched into polar orbits. A Man-Tended Free Flyer is also under consideration by the European Space Agency as a co-orbiting platform with the manned base.

In addition to the development of the manned base and U.S. polar platform, the Space Station program will include development of a Flight Telerobotics System (FTS). The FTS will be a highly automated telerobotic device capable of precise manipulations in space. The FTS onboard the Space Station will increase crew safety and productivity by reducing extravehicular activity (EVA) time, allowing the use of robotics for hazardous tasks, and free crew members for scientific tasks. The FTS will play a key role in the development of automation and robotics (A&R) technologies.

As noted above, a key design objective of the Space Station is to enable hardware and software to evolve in response to inceased user demands and the need for augmented operational capabilities. The Transition Definition activities will provide for systems studies to define options for evolution of the Space Station consistent with future agency missions and for technology developments, primarily in automation and robotics, that will enhance Space Station productivity. These activities are essential for the long-term cost-effective utilization of the Space Station.

The Office of Space Station initiated a definition study during FY 1987 to reevaluate the requirements for an assured crew return capability. This activity, the crew emergency return vehicle definition study, will be continued in FY 1988 and FY 1989 under Space Transportation Capability Development and managed by the Office of Space Flight.

Space Station operations encompass all activities required to maintain the Space Station and platforms for its planned lifetime. This includes logistics support, crew training, mission operations, engineering support, launch processing, and user training and operations. The FY 1988 budget requested funds to support preliminary operations planning. These funds have been deferred based on an assessment that it was premature to initiate operations planning tasks at this time.

Since submission of the FY 1988 budget last year, the Space Station program has completed a series of intensive reviews regarding program content and rationale, flight system configuration, and overall reasonableness of the total cost estimates.

The most comprehensive review was conducted at the request of the President by the NRC Committee on Space Station. The NRC's task was to access NASA's cost estimates for the Space Station program and to examine Space Station mission requirements and alternative configurations. This Committee issued its final report on September 10, 1987. The Committee found that the reviewed baseline configuration was "a satisfactory starting point for the Space Station . . . and reflects thoughtful compromises among the priorities and sometimes conflicting requirements of its early scientific and engineering users." The Committee also stressed the importance of having a robust space transportation system, development of an adequate ground test program and backup hardware policy, strengthened Space Station program management, and emphasis on the operational aspects of the program. Preparation of a new Space Station program cost estimate in early 1988 was also advocated. These recommendations will receive special attention during the upcoming Program Requirements Review. After the Program Requirements Review is completed, NASA will provide the Committee with a revised estimate of the Space Station program's cost and schedule.

The NASA studies include an extensive series of analyses relating to the Space Station operations, led by the Space Station Operations Task Force (SSOTF). The results of the SSOTF's work were sent to Congress in the fall of 1987. Concurrent and subsequent study efforts were also conducted in the areas of operations costs management and Space Station science operations management concepts. These reports were sent to Congress in August and October 1987, respectively. NASA also conducted a transportation study that reviewed the capability of the Shuttle as well as other unmanned launch vehicle systems to provide space transportation in support of on-orbit assembly and Space Station operations. Results of this study were furnished to the NRC and subsequently documented in a report transmitted to Congress in January 1988.

Also, as directed in Congressional legislation, NASA prepared and forwarded to Congress an additional development report: the Space Station program plan for selective design parameters, submitted in April 1987. This report is consistent with and supportive of the revised baseline program's flight hardware configuration and overall transportation, assembly, and operations planning.

Due to the bipartisan budget agreement, the Congress directed a significant reduction in the funding appropriated for the Space Station program in FY 1988. The amount requested by NASA for FY 1988, $767.0 million, was reduced to $425,000,000, including $100 million transferred from 1987 replacement orbiter production funds. After adjustments for a directed realignment between the research and development appropriation and the research and program management appropriation, the revised plan for FY 1988 is $392,300,000.

NASA has developed, and submitted to the Congress in April of 1988, a "Space Station Capital Development Plan" and a "Space Station Program Response to the FY 1988 and 1989 Revised Budgets." These reports include revised program cost estimates, both annual and total, that are consistent with the current budget allocation. These revised estimates include the necessary initial adjustments to program milestones.

In addition, NASA will complete a management plan responsive to the recommendations of the NRC which will also address necessary civil service staffing levels to support the program. The *final* capital development plan and a revised Space Station development plan will be submitted to the Congress following the Program Requirements Review.

This budget requests the funding levels for the Space Station of $967,400,000 for the present budget year, $2,130,200,000 for FY 1990 and $2,912,500,000 for FY 1991. The administration is requesting legislation for a Congressional commitment to a three-year advance authorization and appropriation of Space Station funds for FY 1989 through FY 1991. Later this year, the administration plans to request legislation to establish a total program cost ceiling. These measures on the part of Congress and the administration will provide increased program stability while maintaining cost control discipline for both development and operations. The long-term commitment will help assure potential international participants that the United States will recognize the importance of cooperation on the Space Station program.

In support of the President's policy on the commercial use of space, NASA will, in consultation with the Office of Management and Budget, revise its guidelines on the commercialization of the Space Station to reaffirm, clarify and strengthen its commitment to private sector investment and involvement in the Space Station program. Proposals for commercial involvement in the development of the revised baseline program will be considered in the Program Requirements Review. NASA will give positive consideration to proposals to accelerate private sector investment in Space Station development and operations in the form of either goods or services which have not yet been contracted. Further, NASA will seek to reply on private sector design, financing, construction and operation of future Space Station requirements, including those currently under study.

Space Station—Committee Comments

The Committee strongly supports the development of a permanently manned space station in cooperation with our allies. However, the Committee also realizes that the space station program cannot be fully funded within a constrained NASA budget. To try and develop a space station at the expense of the NASA core programs would be a tragic mistake. The Committee, therefore, authorizes $867,400,000 for FY 1989—$100 million less than the President's budget request—in order to spread the Committee's proposed reductions to the FY 1989 NASA budget request in a fair and equitable manner. The Committee feels strongly that this level of funding is adequate to permit NASA to aggressively initiate Phase C/D of the program—the hardware/development phase.

Since the severe reduction to the space station program in the FY 1988 Continuing Resolution (P.L. 100-203), the Committee has been deeply concerned about the fate of the space station program. The lack of financial commitment to the program has already extended the prposed schedule and has dramatically increased the proposed costs. Today we find ourselves equipped with a standing army ready to start construction of the space station, but this army has considerably less money for hardware development than was originally planned. The reasons for these problems are myriad, but the principal problem is trying to provide sufficient budget resources for a major initiative at a time of severe fiscal constraint.

The irony of this situation is that at the very moment when the budget debate is coming to a head in the Congress, NASA and the State Department have just successfully completed two-and-a-half years of negotiations with ESA Canada, and Japan to enlist their financial support for and participation in the space station program. At this very moment, the final Memoranda of Understanding and Intergovernmental Agreements between the United States and its allies/partners are being reviewed by the administration and prepared for final submission to the Committee for its approval.

The Committee is fully cognizant of the severe budget pressures that confront the Congress and the severe constraints that have been self-imposed on the Congress as a result of last year's Budget Summit. However, the Committee also is well-aware of the importance of the space station program to our national and economic security, technological leadership, and foreign policy standing. The Committee feels strongly that the space station program is a national priority and should be a budget priority. Unfortunately, there does not yet appear to be a consensus in the Congress on that position.

The Committee also believes strongly that FY 1989 is critical to the success of the space station program and to the overall standing of the Nation's civil space program. If the next President finds a well-defined space station program with strong international support, the program's future will be enhanced considerably. If, however, the next President finds a program lacking support or resources, the program's fate would be less certain. Therefore, the Committee has provided a level of funding sufficient to initiate the full-scale development of hardware in FY 1989.

Needless to say, the Committee intends to work diligently in FY 1989 to secure a reasonable level of funding for the space station program and to build a favorable consensus on Capitol Hill for this program. To that end, the Committee strongly urges the President and the White House to lend their full support to help achieve the maximum funding possible for FY 1989. In FY 1988, Congress appropriated only $425 million of a budget request of $767 million. The space station program cannot afford to have a similar action repeated in FY 1989.

As the Committee noted in its FY 1988 NASA Authorization Bill Report (S. Rpt. 100–87), "it is time for the U.S. to realize that our leadership in space has significantly eroded, and, if certain measures are not taken, our space program could experience a significant reduction in vitality and effectiveness." Unquestionably, the top priority of our civil space program is NASA's core program of activities, of which the space station is a singularly important feature. Adequate funding is essential if our civil space program and, in particular, the space station are to achieve the level of success our civil space program enjoyed in years past.

Now is the time for Congress and the administration to realize that NASA's core program, in particular the President's space station initiative, is at great risk and that all of its energy must be devoted to minimizing the FY 1989 NASA budget reductions to a level adequate to support a balanced civil space program.

As stated in section 10 of the bill, the Committee maintains its belief that the space station is a facility that should be used for peaceful purposes in accordance with international law. Accordingly, the Committee has incorporated language in the FY 1989 bill which affirms this position. The same language was included in the FY 1985, 1986, 1987 and 1988 Senate bills and restates Article IV of the 1967 *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Celestial Bodies*. Pursuant to this standard, the Department of Defense (DOD) is perceived to be a user of the space station, and it is recognized that it may conduct research and development activities on the space station facilities.

Finally, the Committee is concerned that definite decisions have not been made concerning whether or not the space station should be metric and whether or not the space station polar platform should be launched on an expendable launch vehicle. The Committee urges NASA to resolve these issues by no later than October 1, 1988, and to report its final decisions and rationales to the Committee.

2. SPACE TRANSPORTATION CAPABILITY DEVELOPMENT—$606,600,000

The Committee authorizes $606.6 million for FY 1989 for space transportation capability development. This is $24,500,000 less than the President's request.

Summary of FY 1989 funding levels

Spacelab	$80,400,000

Upper Stages	153,200,000
Engineering and technical base	158,900,000
Payload operations and support equipment	67,300,000
Advanced programs	45,000,000
Advanced launch systems	6,500,000
Tethered satellite system	23,800,000
Orbital maneuvering vehicle	96,500,000
Total Space Transportation Capability Development	$606,600,00

The principal areas of activity in Space Transportation Capability Development include the Spacelab; the Upper Stages required to place satellites in high altitude orbits; the Engineering and Technical Base support at the manned space flight centers; Payload Operations and Support Equipment for accommodating NASA payloads; Advanced Programs study and evaluation efforts; the development and first flight of the United States/Italian Tethered Satellite System; and the development and first flight of the Orbital Maneuvering Vehicle.

Spacelab was developed jointly by NASA and ESA. It is a major element of the Space Transportation System (STS) that provides a versatile, reusable laboratory which is flown to and from Earth orbit cargo bay. The development program continues with a recertification program to insure flight safety, the procurement of flight hardware to support the flight program and necessary modifications including replacing the onboard computer system.

Upper Stages are required to deploy payloads to orbits and trajectories not attainable by the Shuttle or expendable launch vehicles alone. The program provides for procurement of stages for NASA missions, for technical monitoring and management activities for government and commercial Upper Stages, and a solid rocket motor integrity program to establish an engineering data base for improving the success rate of U.S. built solid stage components.

The Engineering and Technical Base provides the core capability for the engineering, scientific, and technical support required at the Johnson Space Center (JSC), the Kennedy Space Center (KSC), the Marshall Space Flight Center (MSFC), and the National Space Technology Laboratories (NSTL) for research and devleopment activities. Additional requirements above the core level of capability are funded by the benefiting programs.

The Payload Operations and Support Equipment program develops and places into operational status the ground and flight systems necessary to support the STS payloads during pre-launch processing, on-orbit mission operations and, when appropriate, post-landing processing. Included within this program area are the STS support services for NASA payloads, satellite servicing tools and techniques development, flight demonstrations, and multi-mission payload support equipment.

Advanced Programs conducts concept feasibility studies and selected system definitions and preliminary design (Phase B) studies and undertakes related high leverage advanced development to provide the technical and programmatic data to identify evolving space transportation and system requirements and to evaluate new space transportation initiatives. Complementary objectives are to assimilate generic technology and advanced planning activities, and to provide an advanced planning programmatic link between the Office of Space Flight and other NAS program offices. Activity is focused on four major areas—advanced transportation, advanced operations support, satellite servicing and advanced missions. Concept definition and key advanced development are under way and planned in these areas to assess performance, reliability and operational efficiency improvements and to reduce future program risks and development costs through the effective use of new technolgy. Included as part of the Advanced Programs Development Program are definition studies of a Crew Emergency Return Vehicle (CERV) to provide approaches for additional crew return capability from the Space Station manned base.

The Advanced Launch System (ALS), as outlined in the joint DOD/NASA report to Congress, is a joint DOD/NASA program to develop and field this nation's next generation of unmanned launch systems. The ALS program will permit this nation to achieve the goal of reduced cost to space. Both NASA and DOD are moving aggressively forward with ALS and are jointly managing the effort. As directed by Congress in the FY 1988 DOD Appropriations Bill, a total of $70 million has been transferred from DOD to NASA to fund the NASA directed ALS-Propulsion Focused Technology program activities. Within this total, $65,100,000 will be utilized in STS Capability Development, and $4,900,000 will be used in the Research and Program Management Appropriations to fund the necessary support to these propulsion activities. Advanced Program Development will direct and fund study efforts for unique civil mission requirements not satisfied in the joint DOD/NASA ALS baseline design.

The Tethered Satellite System (TSS), a joint Italian-U.S. development effort, will provide a new reusable capability for conducting space experiments and unique tethered applications in regions remote from the Shuttle orbiter. The objectives of the initial TSS mission are twofold: (10 to verify the controlled deployment, operation, and retrieval of the TSS, and (2) to quantify the interaction between the satellite/tether and space plasma in the presence of a current drawn throught the tether.

The development of the Orbital Maneuvering Vehicle (OMV), initiated in 1986, will provide a capability for payload delivery, retrieval, and servicing beyond the reach of the Space Shuttle or the Space Station.

Four dedicated Spacelab flights have been flown on the STS including the first Spacelab reimbursable flight, Deutschland-1 (D–1). In addition, several smaller Spacelab elements have flown on other STS flights as partial payloads. These flights have demonstrated the unique capabilities and benefits offered by many of the Spacelab elements. The Spacelab Astro-1 mission, scheduled for the first quarter of 1989, will be the first Igloo Pallet Configuration of the Spacelab Pallet System. Preparations are now in process for resumption of operational flights for DOD for two dedicated U.S. Materials Science Laboratory flights in FY 1990 and a dedicated U.S. Microgravity Laboratory mission in FY 1992.

In addition to NASA missions, the Spacelab program will also support three reimbursable missions: the U.S. DOD Starlab, the German D–2, and the Japanese SL–J.

In Upper Stages, funding is included for production, launch, flight support, and integration of Inertial Upper Stages (IUS) vehicles to accommodate the TDRS D, E, and F missions, and the Galileo, Ulysses (including a PAM-S vehicle), and Magellan planetary missions. Funding also is included for production of a Transfer Orbit Stage (TOS) vehicle for the Mars Observer mission in the FY 1989 budget. The FY 1989 budget request also supports the Solid Propulsion Integrity Program that was created in 1984 to establish an urgently needed data base for use of composite materials in upper stage motor nozzles and to restore user confidence in U.S. launch systems. The results and finding of this program are being used in the Shuttle Solid Rocket Motor redesign effort. The program scope is being expanded to examine motor bondlines as well as continuing the nozzle efforts.

In Payload Operations and Support Equipment, funding is required to furnish continued payload services for currently scheduled NASA launches. Major NASA payloads receiving support during this year include Hubble Space Telescope, TDRS, Galileo, Ulysses, Magellan, Astro, Long Duration Exposure Facility Retrieval, Upper Atmospheric Research Satellite, and Gamma Ray Observatory. Efforts will continue to provide the means to maintain and repair satellites on-orbit by developing a series of tools, aids, and techniques, and to demonstrate capabilities and methods of improving the efficiency of on-orbit operations. The FY 1989 engineering and technical base request provides for a continuation of the FY 1988 level of support for basic research and development facilities and services at the centers, with an expansion of computational capability by acquiring a class VI computer for use at JSC and increased Safety, Reliability and Quality Assurance (SR&QA) and engineering support at JSC, KSC, and MSFC.

The Advanced Programs effort is focused on four major areas—advanced transportation, advanced operations support, satellite servicing, and advanced missions. Concept definition and key advanced development are under way and planned in these areas to assess performance, reliability, and operational efficiency improvements, and to reduce future program risks and development costs through the effective use of new technology. Advanced transportation study efforts focus on cargo vehicles, manned vehicles, and space transfer vehicles. Studies are under way to define the evolution of manned vehicles, including Space Shuttle enhancement concepts (Shuttle Block II), and next generation concepts (Shuttle II). In addition, definition studies are under way to analyze mission requirements for the design and development of a CERV to provide approaches for additional crew return capability from the Space Station. Advanced operations support systems efforts focus on the study and assessment of innovative ground, flight and on-orbit operations techniques to achieve improved safety as well as reduced life-cycle costs for space transportation and orbital systems. The complementary Advanced Operation Effectiveness activity will focus on demonstration of autonomous and expert systems technology to improve the safety and reduce the costs of Shuttle operations. The satellite servicing study effort, encompassing satellite servicing systems and tether applications, focuses primarily on the development of systems and procedures designed to utilize Shuttle capabilities that are compatible with the Space Station and the OMV. Advanced missions activity will continue to focus, with expanded scope and increased depth, on potential manned and unmanned missions beyond the Space Station. Focused orbital debris studies, augmented by the development of a debris measurement radar, will be continued.

Studies, with a directed focus building upon the joint DOD/NASA ALS baseline design, are planned to examine vehicle and propulsion systems to satisfy national requirements. The ALS-Propulsion Focused Technology program, a NASA-directed element of the core DOD/NASA ALS program, is focused on demonstrating the performance and operating capabilities of critical propulsion system components.

The TSS hardware development was initiated in FY 1984, and systems definition studies were completed in FY 1985. Comprehensive design and requirements validation, procurement of long lead time flight hardware elements and tooling, systems development and integration, and deployer manufacturing and integration will continue through FY 1989. The Italians started satellite and core equipment development in FY 1984. U.S. science instruments for the satellite are being funded in the Physics and Astronomy budget. A cooperative first flight on the Space Shuttle is presently planned for 1991.

The OMV will be a reusable, remotely operated propulsion vehicle with the capability to deliver, retrieve and service payloads and spacecraft deployed at a wide range of altitudes and inclinations. The development contract was initiated in late 1986 with a planned initial capability in 1991. Based on budgetary reductions and current shuttle manifest planning, the initial capability requirement has been rescheduled to 1993. The initial operational use of the OMV is in support of the Hubble Space Telescope servicing requirements. The FY 1989 budget request includes funds for continuation of the design and development, initial testing, and production of flight hardware.

Space Transportation Capability Development—Committee Comments

The Committee authorizes $606,600,000 for Space Transportation Capability Development in FY 1989. This is $24,500,000 less than the President's budget request. The Committee's reduction reflects a general reduction of $25 million to be distributed in a cost-effective manner, a reduction of $6,500,000 to the new ALS line item, and an increase of $7 million to procure a TOS upper stage for the Advanced Communications Technology Satellite, which is scheduled for launch in 1992.

The Committee was pleased to see a significant increase in the number of planned Spacelab missions in the most recent NASA manifest. Spacelab missions offer a unique laboratory environment for research and development and are important precursor missions to the space station.

The Committee also is pleased to see that NASA and the Air Force have reached agreement on ALS development and management plan that is satisfactory to both agencies and the involved

Congressional Committees. This focused technology program will significantly enhance existing launch systems and operations and could lead to significantly improved future launch systems. Despite the fact the majority of the NASA funding for the ALS Propulsion Funding is provided by the Air Force, the Committee intends to oversee closely these activities.

The Committee would like to recognize NASA and the Air Force for their inputs into the Office of Technology Assessment's "Launch Options for the Future: A Buyer's Guide" Special Report, requested by the Committee. The report examines the economic and non-economic criteria for a wide range of space transportation system options and is a most useful document in determining the relationship between U.S. space goals and launch system requirements.

Finally, the Committee is concerned about the substantial cost escalation in the TOS program and its effect on the total estimated costs of the Mars Observer and Advanced Communications Technology Satellite programs. The Committee, therefore, directs NASA to submit by October 1, 1988, a detailed estimate of the current TOS program costs, compared to the original estimate, with a complete explanation of these increases.

3. SPACE SCIENCE—$1,252,300,000

The Committee authorizes $1,252,300,000 for Space Science—Physics and Astronomy, Life Sciences and Planetary Exploration—for FY 1989. This is $45 million less than the President's request.

A. PHYSICS AND ASTRONOMY—$761,600,000

Summary of FY 1989 funding levels

Hubble Space Telescope Development	$102,200,000
Gamma Ray Observatory Development	41,900,000
Global Geospace Science	76,400,000
Advanced X-ray Astrophysics Facility Development (AXAF)	27,000,000
Payload and Instrument Development	77,100,000
Shuttle/Spacelab Payload Mission Management and Integration	61,500,000
Space Station Integrated Planning and Attached Payloads	8,000,000
Explorer Development	82,100,000
Mission Operations and Data Analysis	156,200,000
Research and Analysis	89,100,000
Suborbital Program	45,100,000
Total Physics and Astronomy	[1] $761,600,000

[1] Reflects general reduction of $5 million.

The objectives of the Physics and Astronomy program are to increase our understanding of the origin and evolution of the universe, the fundamental laws of physics, and the formation of stars and planets. Objects studied by the Astrophysics program include distant galaxies and galactic clusters, as well as stars and other structures in nearby galaxies and the interstellar medium in our galaxy. Unusual and exotic phenomena—such as quasars, neutron stars, pulsars and black holes—are of particular interest to the Astrophysics program and are the target of many ground-based and space-based research programs.

Intensive study of our own Sun, with its multitude of time-varying phenomena, provides key answers to a vast range of questions requiring comprehensive research into solar-terrestrial processes and the physics and coupling between the solar wind, magnetosphere, ionosphere, and atmosphere.

The objectives of the Physics and Astronomy program are accomplished with a mixture of large, complex free-flying space missions, less complex Explorer spacecraft, Shuttle/Spacelab flights and suborbital opportunities. In the future, the Space Station will act as a platform for attached payloads and as a servicing point for major free-flying observatories which require assembly, maintenance and refurbishment in orbit. Space-based research allows observations in wavelength regions such as the infrared or the ultraviolet which cannot be carried out on the ground due to the obscuring effects of the atmosphere. Also, observations in the visible light region are vastly improved when conducted above the atmosphere. The entire program rests on a solid basis of supporting research and technology, data analysis, and theory.

Research teams involved in this program are located at universities, industrial laboratories, NASA field centers, and other government laboratories. The scientific information obtained and the technology developed in this program are made available to the scientific communities and the general public for application to the advancement of scientific knowledge, education and technology.

Hubble Space Telescope Development

The Hubble Space Telescope, to be launched by the Space Shuttle in June 1989, will provide an international spaceborne astronomical observatory capable of measuring objects appreciably fainter and more distant than those accessible from the ground, since it will be above the turbulent and absorbent atmosphere. This telescope will be able to resolve spatial features by a factor of 10 better than the typical ground-based optical telescope and will observe the universe at approximately seven times the distances now possible. This means some 350 times the volume of the present universe will be available for study. This increased capability will allow us to address basic questions concerning the origin, evolution, and disposition of galaxies, quasars, clusters, and stars, thus allowing us to significantly increase our understanding of both the early and present universe—its beginning and end.

The Hubble Space Telescope will make a major contribution to understanding the stars and galaxies, the nature and behavior of the gas and dust between them, and the broad question of the origin and scale of the universe. The Hubble Space Telescope will operate in space above the atomospheric veil surrounding the Earth, increasing dramatically the volume of space accessible for observations. With its significant improvements in resolution and precision in light sensitivity and in wavelength coverage, the Hubble Space Telescope will permit scientists to conduct investigations that could never be carried out with ground-based observatories limited by the obscuring and distorting effects of the Earth's atmosphere.

The Hubble Space Telescope will be an automated observatory.

Gamma Ray Observatory Development

The Gamma Ray Observatory (GRO), scheduled to be launched by the space shuttle in March 1990, will study the highest energy electromagnetic radiation emitted from sources in the cosmos. This spectral region represents one of the last frontiers in astronomy to be studied at high sensitivity. Because of their extreme energy, gamma rays are produced by the most energetic and intriguing phenomena occurring in the universe: phenomena occurring in the central energy source region of quasars, in supernovae, near black holes, and on the surface of neutron stars. Gamma rays provide the unique direct signature of all nuclear processes which occur in astrophysics: the synthesis of elements, cosmic rays interacting in the interstellar medium, and transformations involving synthesis of elements, cosmic rays interacting with the interstellar medium, and transformations involving the fundamental particles of physics. GRO will provide new information on phenomena ranging from the enigmatic, and yet unidentified, cosmic gamma ray bursts to the diffuse gamma ray sky background, whose origin must have cosmological significance.

The GRO science and instrumentation rest on a foundation of exploratory investigations and developments from a previous spacecraft, such as the Small Astronomy Satellite-2 (SAS–2, 1972), the High Energy Astronomical Observatories (HEAO's 1 and 3, 1977 and 1979), and the European COS-B (1975). A community of astronomers and physicists has built up the data analysis experience and developed the theoretical concepts to complete the infrastructure required for a successful space mission. Participation in the GRO mission includes the university science community as well as government and industry. International involvement, with a complete Principal Investigator team based in Europe, is extensive.

Global Geospace Science

Global Geospace Science (GGS) will be part of the U.S. contribution to the International Solar Terrestrial Physics (ISTP) program. This program is an international, multi-spacecraft, collaborative science mission designed to provide the measurements necessary for a few and comprehensive understanding of the interaction between the Sun and the Earth.

GGS is a complementary science mission to the Collaborative Solar Terrestrial Research (COSTR) program to provide instruments and launch support and to gain science return in a cooperative effort with ESA and the Japanese Institute of Space and Aeronautical Science (ISAS). The scientific value of this effort will be greatly enhanced by the addition of the two spacecraft proposed in the GGS program. The combined program will include five spacecraft missions: two U.S. spacecraft, *Wind* and *Polar;* two ESA spacecraft, *Soho* and *Cluster;* and one ISAS spacecraft, *Geotail,* most of which are to be launched by NASA.

The GGS mission will measure and model the effects of the Sun on the Earth's space system to enhance our understanding of the processes and flow of energy and matter in the solar energy chain from outer geospace to atmospheric deposition. GGS will also enhance our ability to assess the importance of variations in atmospheric energy deposition from the geospace system to the terrestrial environment. GGS consists of two fully instrumented U.S. spacecraft, *Wind* and *Polar,* making simultaneous measurements in key geospace regions. Instruments and theory investigations were selected through an Announcement of Opportunity to U.S. and foreign investigators. GGS provides the first coordinated geospace measurements in key plasma source and storage regions, multispectral global auroral imaging, and multi-point study of magnetospheric response to solar wind.

Essentially all commitments by the foreign governments are in place, and their development activities have commenced. GGS will allow the United States to become a full partner in the ISTP program, reinforcing our commitments to international cooperation, and is essential to maintaining continued leadership in solar terrestrial physics.

ADVANCED X-RAY ASTROPHYSICS FACILITY DEVELOPMENT

The FY 1989 budget request includes a request for a "new start" for the advnced X-ray astrophysics facility (AXAF). AXAF is the third of four "great observatories" to be proposed by NASA and is a telescope facility designed to observe the universe in the X-ray region of the electromagnetic spectrum.

AXAF is 100 times more sensitive and has 1,000 times more capability for spectroscopy than any previous or planned X-ray mission. AXAF needs to be undertaken immediately in order to fly in concert with the Hubble Space Telescope, which will observe the universe in visible and ultraviolet radiation, and the Gamma Ray Observatory, which will observe in gamma rays. The scientific return of these "Great Observatories" will be enhanced enormously if flown together to observe the whole range of phenomena in the cosmos, from the most tranquil to the most violent, and to provide a complete physical picture of the universe's most enigmatic objects. Moreover, immediate initiation of AXAF will provide a scientific opportunity that is unlikely to be repeated for many generations. The closest supernova to occur near Earth since the invention of the telescope, 400 years ago, was seen last year, and can be studied by AXAF provided that it is launched by 1995, before the X-rays fade. Supernovae are responsible for the origin of all the heavier elements in the unvierse including those essential for life.

The AXAF, with its 1.2-meter class grazing incidence telescope, will double the energy coverage which was provided by the Einstein Observatory (HEAO-2). If approved, AXAF will be launched in 1995 using the Space Transportation System (STS). It will be a long-lived observatory designed for on-orbit instrument replacement and servicing. With the Shuttle, and eventually the Space Station, the United States has the unique capability to maintain this telescope in orbit.

An extensive preparatory program has been completed for AXAF, including completion of 32 months of observatory definition in January 1987, which included the fabrication of the finest X-ray mirror ever built. NASA and industrial teams are in place and ready to proceed with AXAF.

In this era in which U.S. leadership in space is being challenged, a new start for AXAF will provide a bold statement that in the premier scientific discipline of astrophysics, we will be second to none.

Payload and Instrument Development

The recent reorganization of the Office of Space Science and Applications (OSSA) established a new Space Physics Division and placed budget responsibility for all payload development in the appropriate discipline divisions of OSSA. Consequently, funds for development of Physics and Astronomy payloads have been transferred to the newly created Payload and Instrument Development budget line. In addition, funding for reflight of the Imaging Spectrometric Observatory (a Spacelab-3 atmospheric physics experiment) on ATLAS-1 has been transferred to the Environmental Observations Payload and Instrument Development. Spartan funding has also been transferred to the Physics and Astronomy Research and Analysis line to provide additional funding for the Supernova campaign.

FY 1989 instrument development activities support a wide range of instrumentation—from early test, checkout and design of instruments for long duration free-flying missions to international flights of opportunity.

The COSTR program will provide state-of-the-art instrumentation for flight opportunities on international spacecraft and various U.S. spacecraft of opportunity.

The Tethered Satellite System (TSS) will provide a facility for conducting experiments weighing 500 kg or less from distances of 100 km above or below the Space Shuttle. The objective of the initial TSS mission in January 1991 is to verify the controlled deployment, retrieval and on-station stabilization of a satellite tethered from the orbiter and to carry out an electrodynamics experiment using a conducting tether extended 20 km above the orbiter. TSS is an international cooperative project with the Italian government.

The Shuttle experiment to test the theory of relativity will develop a multigyroscope experimentation package to fly as an attached payload on the Shuttle in 1993 as an integral part of the study of relativity.

Astrophysics and Space Physics Payloads include a number of instruments designed for flight on the Space Transportation System. Emphasis will be on technology definition for the High Resolution Solar Observatory (HRSO) as well as instrument development for study of the complex relationships of solar irradiance and the near-Earth plasma environment (Atmospheric Laboratory for Applications and Science—ATLAS) and the diffuse X-ray background and spectra of point and extended sources (Shuttle High Energy Astrophysics Lab—SHEAL).

Shuttle/Spacelab Payload Mission Management and Integration

The primary objective of the Spacelab Payload Mission Management program is to manage the mission planning, integration, and execution of all NASA Spacelab and attached Shuttle payloads.

Mission management activities are continuing for Physics and Astronomy missions including the ASTRO-1 mission and SHEAL.

ASTRO-1 is scheduled for flight in 1989; SHEAL is currently planned for flight in 1992. The primary instrument on SHEAL, a broad-band X-ray telescope, is also under consideration for an early flight on the ASTRO mission in order to make timely observations of the Supernova 1987a.

Mission management activities are continuing on several other space science and applications missions such as the ATLAS. The first of this series is planned for flight in 1991. Other examples include flight of an imaging radar in the early 1990's; a series of Spacelab Life Sciences Missions (SLS), the first scheduled for launch in December 1989; a joint microgravity mission with the Japanese (SL-J); a series of cooperative International Microgravity Laboratories (IML's); and flight of the on-going series of Materials Science Laboratories (MSL's).

Space State Integration Planning and Attached Payloads

The primary objective of the Space Station Integration Planning and Attached Payloads program is to initiate the necessary planning, definition and development of payloads and missions as OSSA begins its preparations as a future major user of the Space Station complex. This includes the definition of attached payloads suitable for deployment on the early Space Station, as well as the definition of integration and operational requirements, in anticipation of the new, integrated methods of conducting scientific research which the Space Station will offer.

Studies continue to define the end-to-end science operations requirements for the Space Station era (i.e., the cycle from identification of science requirements through mission planning and operations to dissemination, analysis and archiving of data). Studies also continue to determine the best use of Space Station resources (e.g., power, crew time, volume, data handling capabilities, pointing capabilities) vis-a-vis science requirements. Potential attached payloads have been identified for further feasibility and definition and appropriate studies are under way.

The two-year study phase for Space Station Integration Planning activities will be completed in FY 1988. In FY 1989, definition and development will continue on those attached payloads selected for early flight on the Space Station. Additionally, Space Station payload development activities are augmented in FY 1989 in the cognizant science disciplines where the payloads, hardware and support equipment will be defined and developed through a judicious program of Spacelab test flights. They include facilities and instrumentation for microgravity experiments, as well as Life Sciences hardware, support equipment and studies, and Advanced Technology Development for the polar platform payload (Earth Observing System). The total augmentation for Space Station related payload activities included in the OSSA FY 1989 budget is approximately $50 million.

Explorer Development

Investigations selected for Explorers are usually of an exploratory or survey nature, or have specific objectives not requiring the capabilities of a major observatory.

Explorers under development will study the properties of the cosmic microwave background, which is important for understanding the early universe and cosmology, survey the sky in the extreme ultraviolet for the first time, and measure time variable phenomena in x-ray sources. The Explorer program also provides a means of developing instruments for "payload-of-opportunity" missions, such as those involving other federal agencies or international collaboration.

The San Marco-D mission, a cooperative project with Italy, was launched on March 25, 1988, on a Scout expendable launch vehicle. The Cosmic-Ray Isotope Experiment (CRIE) will be included in the Combined Release and Radiation Effects Satellite (CRRES), an Air Force Mission now scheduled for launch in 1990.

In FY 1986, a new cooperative mission called Solar-A was initiated with the Japanese. Solar-A will be launched in 1991 to study the Sun during the upcoming solar maximum.

In FY 1988, development continues on the Cosmic Background Explorer (COBE) scheduled for launch on a Delta in February 1989, on the Extreme Ultraviolet Explorer (EUVE) scheduled for launch on a Delta in August 1991, and on the X-ray imaging instrument to be flown on the German Roentgen Satellite (ROSAT) scheduled for launch on a Delta in February 1990

Definition and design will continue in FY 1988 on the X-ray Timing Explorer (XTE). This mission, the last currently planned major effort in the Explorer line, can be ready for launch as early as 1983. During FY 1986, a "Dear Colleague" letter was issued to obtain proposals for future Explorers. Over 43 were received and are currently being evaluated for further definition.

In addition to the traditional "Delta-Class" Explorer missions NASA issued on May 9, 1988, an Announcement of Opportunity for Scout-class Explorer missions. While subject to more stringent constraints than Delta-class missions (weight, telemetry, power, etc.), it is anticipated that a significant number of scientifically exciting missions can utilize this capability and be developed on a short time-scale. Following a peer review of proposals, it is anticipated that several Scout missions will be selected for development, with the initial one being launched as early as 1991.

Mission Operations and Data Analysis

The purpose of the mission operations and data analysis effort is to conduct operations and analyze data received from physics and astronomy spacecraft after launch. The program also supports the operation of a number of spacecraft after their originally planned objectives have been achieved for purposes of conducting specific investigations that have continuing high scientific significance. The funding supports the data analysis activities of the many investigators at universities and other research organizations associated with astrophysics and space physics operational satellite projects. Actual satellite operations, including control center and related data reduction and engineering support activities, are typically carried out under a variety of mission support or center support contracts.

In addition to the normal support required for mission operations, the Hubble Space Telescope program encompasses several unique aspects which must be provided for in advance of the launch. The Hubble Space Telescope is designed to operate for more than a decade, using the Space Shuttle/Orbital Maneuvering Vehicle combination and/or Space Station for on-orbit maintenance of the spacecraft and in-orbit changeout or repair of the scientific instruments.

The Hubble Space Telescope will be used primarily by observers selected on the basis of proposals submitted in response to periodic solicitations. Since operations will be carried out through an independent Hubble Space Telescope Science Institute. The Institute will operate under a long-term contract with NASA. While NASA will retain operational responsibility for the observatory, the Institute will implement NASA policies in the area of planning, management, and scheduling of the scientific operations of the Hubble Space Telescope.

Initiation of the definition and implementation of a unified data system will be undertaken. This unified data system will ensure the fullest access and exploitation of the various mission data sets, with emphasis on the wealth of data to be returned by the Great Observatories. An initial definition process involving extensive inputs from the astrophysical community has now been completed, and FY 1989 funding in the Mission Operations and Data Analysis (MO&DA) area will enable the principal elements of this essential system to be put in place.

Research and Analysis

The research and analysis program provides for the preliminary studies required to define missions and/or payload requirements, as well as providing a research and technology base necessary to define, plan and support flight projects.

The objectives of the research and analysis program's supporting research and technology activities include optimizing the return expected from future missions, enhancing the value of current space missions, developing theories to explain observed phenomena and predict new ones; and continuing the acquisition, analysis and evaluation of data from laboratories, balloons, rockets and spacecraft activities.

The space research and technology program carries out its objectives through universities, non-profit and industrial research institutions, NASA centers and other government agencies.

The advanced technological development (ATD) activities, on the other hand, support detailed planning and definition of potential new physics and astronomy missions. ATD activities assure that future missions address the scientific questions most important to the evolution of knowledge in the field and that those missions use the appropriate technology and techniques.

Candidate missions for the 1980's and early 1990's that require ATD activities include the AXAF and the Space Infrared Telescope Facility (SIRTF).

Suborbital Program

The suborbital program uses balloons, aircraft, and sounding rockets to conduct versatile, relatively low cost research of the Earth's ionosphere and magnetosphere, space plasma physics, stellar astronomy, solar astronomy, and high energy astrophysics. Activities are conducted on both a national and on an international cooperative basis.

Forty-four suborbital rockers are currently scheduled for launch in FY 1988. Included in this number are eight NASA launches in Greenland as a follow-up to the FY 1985 effort. In addition, 72 C-141 aircraft missions are planned, including support of the SN 1987a Supernova campaign with additional flights in the southern hemisphere. FY 1988 activities continue the study of a Stratospheric Observatory For Infrared Astronomy (SOFIA) as a potential follow-on for the C-141 in the 1990's. SOFIA would incorporate a three-meter class infrared telescope mounted in a suitable aircraft.

The Balloon Program provides a cost-effective means to test flight instrumentation in the space radiation environment and for making observations at altitudes which are above most of the water vapor in the atmosphere. Balloon experimentation is particularly useful when studying infrared astronomy.

The Balloon Program funding is required for purcahse of balloons, helium, launch services, tracking and recovery, as well as for maintenance and opertions of the National Scientific Balloon Facility (NSBF) at Palestine, TX. This facility supports the launch of about 80 percent of NASA's balloon payloads, and it is the nation's primary means for carrying out large scientific balloon operations. Funding for the experiments flown on balloons is provided from other research and technology programs supporting the various scientific disciplines.

Funds for 1989 will provide for continuation of the sounding rocket, Spartan, and balloon programs including management and operation of the NNSBF in Palestine, Texas. This funding is also required to continue definition activitives for balloon improvement and long-duration balloon flights. In FY 1989, the Airborne Science and Applications funding will be used to continue flights of the Kuiper Airborne Observatory.

Physics and Astronomy—Committee Comments

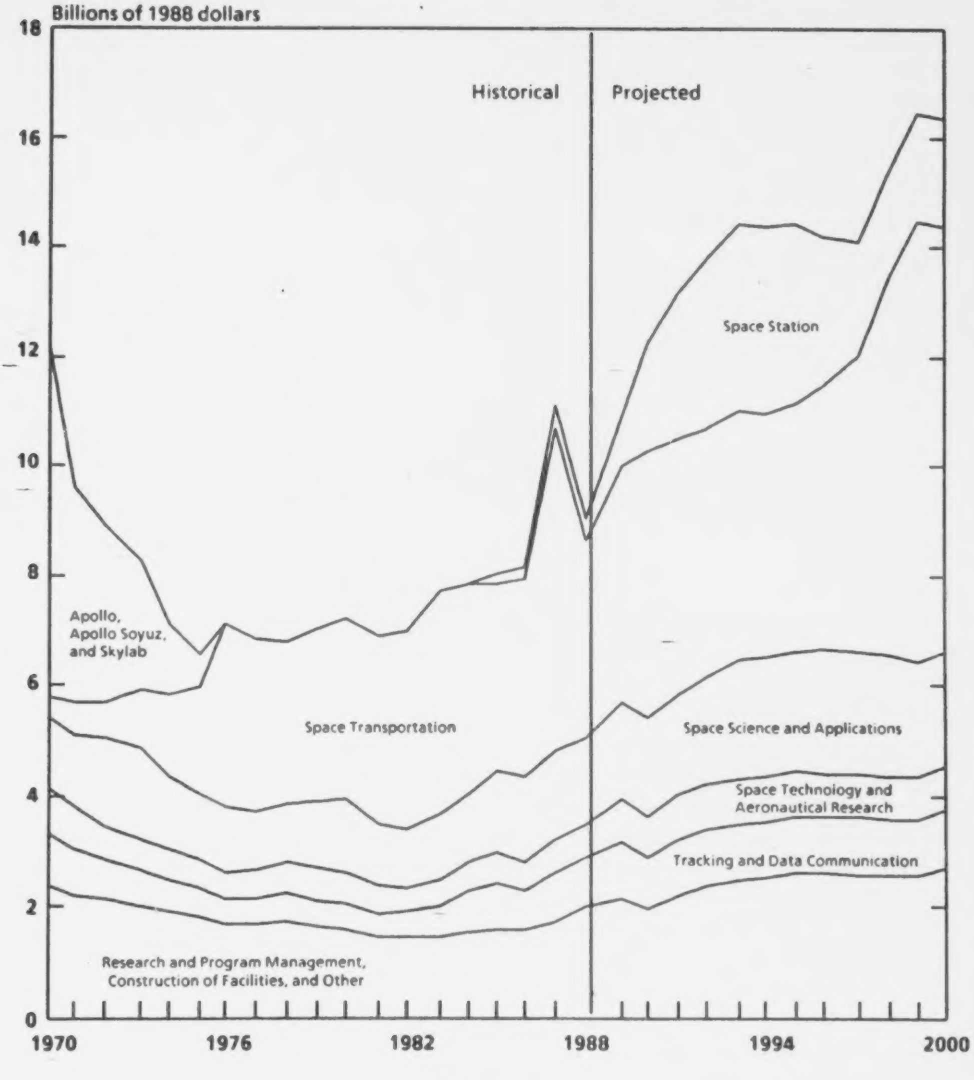
The Committee authorizes $761,600,000 for Physics and Astronomy in FY 189. This is $30 million les than the President's budget request. The Committee's proposed reduction constsists of a $5 milion general reduction and a rephasing of the GGS program, a FY 1988 new start, that results in a $25 million reduction.

Notwithstanding the recommended reduction of $25 million from the GGS budget request, the Committee would like to indicate that this in no way reflects diminished support of the program. The Committee still strongly endorses the GGS program and the participation of the United States in the ISTP program. Unfortunately, the current status of the GGS program provides an opportunity for a FY 1989 budget reduction.

As part of its discussion of the FY 1989 Physics and Astronomy budget, the Committee applauds the management and staff of NASA's OSSA for their efforts to formulate a strategic plan, with specific goals and evaluation criteria, for space science and applications. The "Office of Space Science and Applications Strategic Plan 1988" is a most useful document and a honest effort to instill more order and predictability in the space science and applications program.

As can be seen in the illustration below, taken from the recent CBO Report "The NASA Program in the 1990s and Beyond," the space science and applications program has experienced severe fluctuations since 1970 and needs to experience real growth in the future years if the United States is to retain its leadership in space science. The Committee strongly supports NASA's space science and applications programs, yet believes that our civil space program needs a broader base of support if the visions of OSSA are to become realities. That is one of the principal reasons why the Science, Technology, and Space Subcommittee conducted a field hearing on March 7, 1988, in Boston, Massachusetts, on Space Science and Applications.

Summary Figure 1.
NASA Budget: Historical and Projected (the "Core Program")



SOURCES: Historical data, NASA budget plans as presented in *NASA Budget Estimates* for various years, and Congressional Budget Office projections.

In light of certain problems of the past and, in particular, the hardships suffered by the space science community as a result of the shuttle grounding, the Committee believes that FY 1989 funding for the space science and applications programs is particularly critical. The Committee continues to support the conclusions of the NASA Advisory Council report, "The Crisis in Space and Earth Science," and the recommendations of the Rogers Commission concerning the importance of a mixed fleet. The Committee believes that it has provided sufficient resources to support a balanced and robust space science and applications program in FY 1989, and the Committee hopes 1989 will be the "Year of Space Science" with the successful launch of the Hubble Space Telescope and the Magellan and Galileo missions.

In the area of Physics and Astronomy, the Committee is pleased to endorse AXAF as a new start in FY 1989. The third of the great observatories, AXAF will be a space-based observatory equipped with special mirrors capable of forming images of astronomical objects in x-ray light. AXAF will produce pictures 10 times sharper, will be able to detect sources 100 times fainter, and will be 1,000 times more sensitive than its predecessor—the Enstein High Energy Astronomy Observatory. In addition, AXAF will help the United States reacquire its world leadership position in astrophysics.

The Committee should indicate that despite its strong support of AXAF, the recent experience with cost overruns and management problems in the Hubble Space Telescope Program are cause for concern. Accordingly, the Committee intends to oversee the AXAF program very closely.

The Committee is pleased to support NASA's request for an augmentation for the Explorer Program in FY 1989 and applauds NASA's decision to initiate the procurement of Scout-class expendable launch vehicles for these missions characterized by their low costs and quick return of scientific data. This initiative by NASA provides greater balance to the NASA manifest between the flight of small missions and large missions. Needless to say, the Committee looks forward to the 1989 launch of the COBE mission on a Delta expendable launch vehicle.

The Committee reiterates its strong support of the mission operations and data analysis, as well as research analysis line items, the lifeline of the university space science community, and is pleased to support a slight increase in the suborbital program, another program of significant value to the members of the space science academic community.

Finally, the Committee reiterates its strong support of the Gravity Probe B mission and the innovative management approach being used to implement this program. The Committee strongly supports the Gravity Probe B project and recommends $22 million for this activity in FY 1989.

B. LIFE SCIENCES—$91,700,000

The Committee authorizes $91,700,000 for Life Sciences in FY 1989. This is $10 million less than the President's request.

Summary of FY 1989 funding levels

Life Sciences Flight Experiments	$54,500,000
Research and Analysis	42,800,000
Total Life Sciences	[1] $91,700,000

[1] Reflects general reduction of $5.6 million.

The goals of the Life Sciences program are to advance knowledge in all areas of space life sciences and to develop medical and biological systems which enable human habitation in space. Results from the research program are applied to: the immediate needs of maintaining astronaut health and productivity; understanding the response of biological mechanisms to weightlessness; the design of controlled ecological life support systems; understanding the origin, evaluation and distribution of life in the universe; and understanding the biosphere of the planet Earth.

Continuing support of the Life Sciences program is essential to: understand the basic biological mechanisms of gravitational responsivity; evolve the critical technologies necessary to enable long-term piloted space flight; and develop the capability to sustain a permanent manned presence in space. The research program includes ground-based and space research efforts which are mutually supportive and integrated. This research program also studies fundamental biological processes and space-related medical problems through a variety of disciplines and techniques.

The Life Sciences research and analysis program includes five major elements: (1) space medicine, which addresses the health and well-being of space crews by seeking to understand and prevent adverse physiological changes which occur in space flight and upon return to Earth; (2) space biology, and integrated basic science research program that studies the fundamental mechanism of gravitational interaction with all orders of plants and animals in flight and ground experiments; (3) controlled ecological life support systems, a program of research and critical technology development for life support systems necessary to maintain life in space autonomously for long periods of time; (4) exobiology research, which is directed toward understanding the origin and distribution of life and life-related molecules on Earth and throughout the universe; and (5) biospheric research, which explores the interaction between life on Earth and its physical and chemical environment.

The Life Sciences Flight Experiment program supports the research and analysis program with the selection, definition, in-flight execution, data analysis and reporting on medical and biological investigations in space involving humans, animals and plants. Experiments are currently conducted on the Shuttle and Spacelab and are being readied for conduct on the Space Station. An international cooperative program, the U.S./U.S.S.R. Working Group in Space Biology and Medicine, pursue investigations of joint interest.

Life Sciences Flight Experiments

The objective of the Life Sciences Flight Exeriment program is to assimilate information and scientific questions from various life sciences disciplines and develop payloads designed to expand the understanding of the basic physiological mechanisms involved in adaptation of weightlessness. The program includes selection, definition, in-flight execution, data analysis and reporting on medical and biological investigations involving humans, animals and plants.

Funding for FY 1989 is required for the final preparation and flight of approved experiments on the first dedicated Life Sciences mission (Spacelab Life Sciences-1 (SLS–1)) which is scheduled to be launched in FY 1991 and will concentrate on studies of human and animal biomedical responses, with emphasis on cardiovascular, bone metabolism and vestibular functions. SLS–1 will be unique in several respects: it will be the first Shuttle/Spacelab mission dedicated entirely to life sciences, and it will involve highly skilled scientists as payload specialists, thus permitting the use of numerous experimental techniques and procedures never before utilized in space.

Final preparations are also under way to support the flight of the first International Microgravity Laboratory (IML–1) mission in 1990. Approximately 50 percent of the payload relates to space life sciences, with the United States focus on plants, neurovestibular studies, human performance, radiation and cellular differentiation.

Efforts will continue on definition and development of new experiments (selected through the Announcement of Opportunity (AO) process) and hardware that will be flown on future Spacelab/Shuttle missions—i.e., Shuttle mid-decks, the Japanese SL–J mission, the second dedicated life sciences mission (SLS–2), the German D–2 mission, IML–2, SLS–3, and the DOD Starlab mission. Collaboration with the Soviet Union on its COSMOS biosatellite program will continue with joint research on the next COSMOS flight in 1989.

To ensure that the Space Station will serve life sciences research objectives, studies will be conducted in FY 1989 to determine how space biology research will be accommodated on the Space Station, as well as to define instrument and facility requirements.

In FY 1989, research efforts will be increased on the feasibility of extending operational tours of duty of flight crews on the Space Station in order to achieve greater cost-effectiveness. The program will decrease transportation costs by helping to reduce yearly Shuttle flights needed to support crew rotations on the Space Station from eight to an estimated four to five. It will allow more effective use of human resources by maintaining crew health and productivity with countermeasures that minimize impact on in-flight crew time.

In FY 1989, development will begin on an integrated centrifuge facility that will support a broad spectrum of life sciences research using small animals and plants. For the first time, it will provide continuous on-board 1–G control that can separate influences of weightlessness from other effects of space flight. It will allow scientists to test the response of living organisms to operational forces at various stages of adaptation to weightlessness.

Research and Analysis

The research and analysis activity supports Life Sciences program goals of advancing knowledge in all areas of space life sciences and developing medical and biological systems which enable human habitation in space. The program is composed of five elements: (1) space medicine; (2) space biology; (3) controlled ecological life support systems research; (4) exobiology; and (5) biospheric research.

In FY 1989, the Space Medicine program will resume collecting information on occupational exposure in microgravity on each Shuttle flight and conduct in-flight clinical testing of countermeasures, especially in the area of vestibular dysfunction, cardiovascular deconditioning and muscular atrophy. Resolving problems associated with the initial adaptation to weightlessness, such as space motion sickness and fluid shifts, will continue to be of high priority.

In conjunction with NASA's development of the Space Station, the Space Medicine program will support extended duration crew operations in space with estensive research in the physiological changes associated with longer exposure to weightlessness. Bone demineralization, muscle atrophy and cardiovascular deconditioning will be studied in ground-based simulation so appropriate countermeasures can be designed. This accelerated program of directed research, bed rest studies and protocol development and evaluation will allow more effective use of human resources in space by developing physiological countermeasures that minimize impact on inflight crew time. Critical technology requirements will be addressed, and research on implementation will be initiated.

In FY 1989, OSSA will collaborate with the Office of Aeronautics and Space Technology on NASA's proposed new initiative: Project Pathfinder. The Project will research critical path elements for long-term manned missions in order to inform policymakers of the requirements (as well as uncertainties, risks and technological issues) involved in such efforts as a lunar base or manned Mars mission. Life science research will be directed to the Humans in Space element of Project Pathfinder and focus on the areas of human performance, extravehicular activity and life support.

In FY 1989, the Space Biology program will concentrate ground research on: developing working models of functioning gravity-sensing neural (information) networks to understand neurosensory processing in microgravity; understanding the physiological side effects of centrifugation in preparation of use of the Shuttle/Space Station centrifuge as a research tool; and identifying the cellular events of the gravity-perception mechanism in plants.

The Controlled Ecological Life Support Systems program will continue to investigate basic biological processes and physical methods to control the interior environment of manned spacecraft, and the Exobiology program will emphasize the development of new flight experiment concepts to investigate models of early Solar System evolution and mechanisms for the synthesis of biologically significant molecules in space.

In FY 1989, definition and design phases will be completed in the program's microwave observing project which will analyze microwave signals in space for evidence of advanced life elsewhere in the galaxy. Funds will be used to begin the development phase of signal processing systems which will be used with existing radio astronomy facilities and NASA's Deep Space Network antennas.

Life Sciences—Committee Comments

The Committee authorizes $91,700,000 for Life Sciences in FY 1989. This is $10 million less than the President's budget request. This $10 million reduction is achieved by a general reduction of $5,600,000 and a deferral to FY 1990, without prejudice, of the Search for Extraterrestial Observing Project. This deferral will result in a reduction of $4,400,000.

The Committee is pleased to augment the Life Sciences budget by $22 million over the FY 1988 appropriation. This increase reflects the Committee's strongly held view that the Life Sciences program and budget must be expanded if the Nation is to maintain a permanently manned presence in space or to undertake long duration missions to other planetary bodies.

C. PLANETARY EXPLORATION—$399,000,000

The Committee authorizes $399 million for Planetary Exploration in FY 1989. This is $5 million less than the President's request.

Summary of FY 1989 funding levels

Galileo Development	$61,300,000
Magellan	33,900,000
Ulysses	10,300,000
Mars Observer	102,200,000
Mission Operations and Data Analysis	112,700,000
Research and Analysis	83,600,000
Total Planetary Exploration	[1] $399,000,000

[1] Reflects general reduction of $5 million.

The Planetary Exploration program encompasses the scientific exploration of the solar system including the planets and their satellites, comets and asteroids, and the interplanetary medium. The program objectives are: (1) to determine the nature of planets, comets, and asteroids as a means for understanding the origin and evolution of the solar system; (2) to understand the Earth better through comparative studies with the other planets; (3) to understand how the appearance of life in the solar system is related to the chemical history of the solar system; and, (4) to provide a scientific basis for the future use of resources available in near-Earth space. The strategy that has been adopted calls for a balanced emphasis on the Earth-like inner planets, the giant gaseous outer planets, and the small bodies (comets and asteroids). Missions to these bodies start at the level of reconnaissance to achieve a fundamental characterization of the bodies, and then proceed to levels of more detailed study.

Galileo will be launched on a Shuttle/Inertial Upper Stage (IUS) combination in October 1989 on a trajectory using gravity assists at Venus and Earth. The comprehensive science payload will extend our knowledge of Jupiter and its system of satellites well beyond the profound discoveries of the preceding Voyager and Pioneer missions. During twenty-two months of operation in the Jovain system, Galileo will inject an instrumented probe into Jupiter's atmosphere to make direct analysis, while the orbiter will have the capability to make as many as ten close encounters with the Galilean satellites.

Ulysses is a joint NASA and ESA activity. The mission will carry a package of experiments to investigate the Sun at high solar latitudes that cannot be studies from the Earth's orbit. Ulysses will be launched in October 1990 using the Shuttle and IUS/PAM-S launch stages.

Magellan will provide global maps of the cloud-shrouded surface of Venus, including its land forms and geological features. Using a synthetic aperture radar to pentrate the planet's opaque atmosphere, Magellan will achieve a resolution sufficient to identify small-scale features and to address fundamental questions about the origin and evolution of the planet. Magellan will also obtain altimetry and gravity data to accurately detemine the planet's gravity field as well as internal stresses and density variations. With these data, the evolutionary history of Venus can be compared with that of the Earth. Magellan is scheduled for launch in April 1989 from the Shuttle with an IUS.

Mars Observer, schedued for launch in 1992, will follow up on the earlier discoveries of Mariner 9 and Viking and will emphasize the geologic and climatic evolution of this complex planet. The mission will utilize a modified Earth-orbiting spacecraft, thereby benefiting from the previously developed technology.

The Planetary Explorations program is also founded on a coordinated ground-based research and analysis effort. Research and analysis activities will continue to maximize the scientific return from both ongoing and future missions and from such Earth-based activities as lunar sample and meteorite analysis, telescopic observations, theoretical and laboratory studies, and instrument definition. This program strives for interdisciplinary coordination among various research groups and for the wide dissemination of scientific results. A close coupling is also maintained between the research programs and planning activities that are undertaken to define the scientific rationale and technology needed for future missions. The program also supports the growing involvement of U.S. scientists as participants on foreign-sponsored missions.

Galileo Development

The objective of the Galileo program is to conduct a comprehensive exploration of Jupiter and its atmosphere, magnetosphere, and satellites through the use of both remote sensing by an orbiter and *in situ* measurements by an atmospheric probe. The scientific objectives of the mission are based on recommendations by NAS to provide continuity, balance, and orderly progression of the exploration of the solar system.

The orbiter and probe will be launched together in October 1989 as a single combined payload using a shuttle/IUS combination on an initial trajectory toward Venus, followed by two Earth swingbys. The three gravitational assists will provide the energy required for a trajectory to Jupiter not otherwise obtainable with this launch vehicle. When the orbiter arrives at Jupiter in November 1995, it will provide remote sensing of the probe entry site and provide the link for relaying the probe data back to Earth. Twenty-two months of orbital operations will follow during which both Jupiter's major satellites and the dynamic magnetosphere will be extensively mapped. During this time ten close flybys of Jupiter's four major satellites are targeted.

The Galileo flight system will be powered by two general purpose heat-source Radioisotope Thermoelectric Generators (RTGs) developed by the Department of Energy. The orbiter will carry approximately 100 kg of scientific instruments and the probe will carry approximately 25 kg of scientific instruments.

Funds for FY 1989 will provide for completion of spacecraft system testing and for preparing the spacecraft to be shipped to KSC for initiation of integration with the IUS and Shuttle. Mission operations software development and testing will also continue in preparation for a launch in October 1989.

Magellan

The objective of the Magellan mission is to address fundamental questions regarding the origin and evolution of Venus through global radar imagery of the planet. Magellan will also obtain altimetry and gravity data to determine accurately the planet's gravity field as well as internal stresses and density variations. The detailed surface morphology of Venus will be analyzed to compare the evolutionary history of Venus with that of the Earth.

The Magellan spacecraft will carry a single major scientific instrument, a synthetic aperture radar, which will be used to obtain high resolution (120 to 200 meter) images of the planetary surface as well as altimetric data. Gravity data will be obtained by processing radio signals from the spacecraft. Spacecraft development is making extensive use of existing designs, technology, and residual hardware. For example, the spacecraft will use an existing spacecraft structure, large antenna, and propulsion components from the Voyager program.

In April 1989, the Magellan spacecraft will be launched by the Shuttle/IUS on a direct trajectory to Venus. Arriving at Venus in July 1990, the spacecraft will perform a retropropulsive maneuver and enter a near-polar elliptical orbit. After an initial check-out period, the spacecraft will map a major portion of the planet over a 243 day period (one Venus year) with a ground resolution of about 150 meters.

During FY 1988, spacecraft structural testing will be initiated, the flight model of the radar instrument will be delivered for integration with the spacecraft, the spacecraft assembly will be completed and environmental testing will be initiated for the entire spacecraft flight system. Integration of the mission operations system will be completed, to be followed by initiation of operations testing and training preparatory for launch.

In FY 1989, the spacecraft will be shipped to KSC following final testing. Upon arrival, the spacecraft wil be integrated with the IUS and Shuttle and undergo final preparation prior to launch in April 1989.

Ulysses

Ulysses is a joint mission of NASA and ESA. ESA is providing the spacecraft and some scientific instrumentation. The United States is providing the remaining scientific instrumentation, the launch tracking support, and the RTG. The mission is designed to obtain the first view of the Sun above and below the plane in which the planets orbit the Sun. To provide a better understanding of solar activity on the Earth's weather and climate, the mission will study the relationship between the Sun and its magnetic field and particle emissions (solar wind and cosmic rays) as a function of solar latitude.

Ulysses was restructured in FY 1981 from a two spacecraft mission—one provided by the United States and one provided by ESA—to a single ESA spacecraft mission. However, the U.S. participation in the program remains substantial. NASA is responsible for five of the nine principal investigator instruments, and three of the four European investigations have U.S. co-investigators.

The Ulysses launch is planned for October 1990, using the Shuttle and IUS/PAM-S launch stages, and its mission will end in July, 1995. During 1988, documentation of the spacecraft/launch vehicle interface will be completed, while support to ESA will continue in order to make the spacecraft compatible with the new upper stage configuration. Launch approval activities involving the RTG and support for retesting the spacecraft and the science instruments will also be continued.

Funding for 1989 will support launch approval activities for the Radioisotope Thermoelectric Generators (RTGs). Periodic testing of the spacecraft and science instruments will also continue.

Mars Observer

The Mars Observer mission is the first in a series of planetary observer missions utilizing a lower cost approach, to inner solar system exploration. This approach, which was recommended by NASA's Solar System Exploration Committee, starts with a well defined and focused set of science objectives and uses modified production-line Earth-orbital spacecraft and instruments with previous space flight heritage. The objectives of the Mars Observer mission are to extend and complement the data acquired by the Mariner and Viking missions by mapping the global surface composition, atmospheric structure and circulation, topography, figure, gravity and magnetic fields of Mars to determine the location of volatile reservoirs and observe their interaction with the Martian environment over all four seasons of a full Martian year.

The limitation on the number of launch opportunities through 1990 and the further restrictions placed on scheduling by timing requirements for planetary launches have necessitated delaying the planned launch of Mars Observer from 1990 until the following planetary opportunity, 25 months later. The current plan is to launch the mission in 1992 with a Transfer Orbit Stage. The spacecraft will be inserted into a near-polar Martian orbit in 1993, from which it will carry out geochemical, geophysical, and climatological mapping of the planet over a period of a full Martian year, which is about two Earth-years.

In FY 1988, it is planned to continue detailed design of the instrument hardware and system design of the overall mission and to complete design of the Payload Data Subsystem. Detail design of the spacecraft and parts and subassembly procurements will be continued.

Funding for 1989 will support the completion of spacecraft and instrument designs. Initial hardward fabrication for both the spacecraft and instruments will also begin. Funding is also included for the procurement of additional spacecraft and instrument spares.

Mission Operations and Data Analysis

The objectives of the mission operations and data analysis activities are in-flight operation of planetary spacecraft and the analysis of data from these missions. Currently, two major classes of planetary spacecraft are operating—the Pioneer and the Voyager spacecraft. The planetary flight support activities are those associated with the design and development of planetary flight operation systems and other activities that support the mission control, tracking, telemetry, and command functions for all planetary spacecraft.

The two Voyager spacecraft are now exploring the outer solar system on trajectories that will take them into interstellar space. Voyager 1 continues to provide data on the interplanetary medium in that distant part of the solar system. In January 1986, Voyager 2 made a close flyby of the planet Uranus, the first time this planet has ever been visited by a spacecraft. During this flyby, it made detailed observations of the planet, its rings, and moons. Upon completion of the Uranus encounter, the spacecraft began its path to the planet Neptune, where, in 1989, it will provide us with our first close look at this distant planet.

Pioneers 10 and 11 continue to explore the outermost solar system. Pioneer 10 will soon enter the unexplored region beyond Pluto where the Sun's influence is secondary to those of true interstellar space. These spacecraft will continue the search for gravitational evidence of a tenth planet. Pioneers 6–9 are still collecting information on the interplanetary magnetic field and solar wind as they orbit the Sun.

The Pioneer Venus orbiter continues to obtain data on Venus' atmosphere and magnetosphere and its interaction with the Solar Wind. In late 1985, the spacecraft's spin axis was adjusted to allow ultraviolet observations of Comet Halley. The Pioneer Venus was the only spacecraft able to observe the Comet at its closest approach to the Sun, thus providing critical enhancements to the data gathered by foreign spacecraft.

The planetary flight support activities include the procurement, operation and maintenance of mission operations and general purpose scientific and engineering computing capabilities at the Jet Propulsion Laboratory (JPL). In addition, the activity supports the development of the Space Flight Operations Center (SFOC) at JPL. This facility will be a versatile, cost-effective means for carrying out multimission data acquisition, telemetry, image processing, and for commanding of planetary and orbital spacecraft.

Funding for FY 1989 is required for the continued operation and data analysis activities in support of the Pioneer missions as well as the August 1989 Voyager/Neptune encounter. Operations activities will also begin for the Magellan mission, which will be launched in April 1989. Development activities will also continue on the SFOC at the Jet Propulsion Laboratory.

Research and Analysis

The research and analysis program consists of four elements required to: (1) assure that data and samples returned from flight missions are fully exploited; (2) undertake complementary laboratory and theoretical efforts; (3) define science rationale and develop required technology to undertake future planetary missions; and (4) coordinate an International Halley's Comet Watch and provide co-investigator support to ESA's Giotto mission, which encountered Halley's Comet in 1986.

The supporting research and technology activity includes planetary astronomy, planetary atmospheres, planetary geology/geophysics, planetary materials/geochemistry, instrument definition, and U.S. scientist participation on foreign missions.

At present, the instrument definition activity is directed toward ensuring maximum scientific return from future missions by the definition and development of state-of-the-art scientific instrumentation, which are optimized for such missions. At the same time, the support for U.S. science investigators on foreign missions currently is being provided for U.S. participation on the U.S.S.R. Phobos missions.

The objective of the advanced program activity is to provide planning and preparation for the systematic exploration of the solar system on a scientifically and technically sound basis. Prospective planetary missions are identified and defined through long-range studies, the technological and fiscal feasibility is evaluated, and the scientific merit is determined through interaction with the scientific community. The strategy for future solar system exploration has been developed by the Solar System Exploration Committee, an advisory group, which has recommended a comprehensive program of missions to the inner and outer solar system.

The Mars Data Analysis program continues to support analysis of data obtained by Viking and earlier missions so that we are scientifically prepared for the next phase of Mars exploration. It also supports the establishment of a Planetary Data System which will permit the archiving of these and all other data products in a manner which will promote and facilitate their use.

During FY 1989, research efforts will continue in the areas of planetary astronomy, planetary atmospheres, planetary geology/geophysics, planetary materials/geochemistry, instrument definition, Mars data analysis, and in the development of required technology to undertake future missions. Ground telescope observations will provide data complementary to that obtained from the flight missions, with emphasis on the outermost planets, comets and asteroids. A variety of efforts will be pursued to improve our understanding of planetary atmospheres, including laboratory studies of reactions in deep planetary and tenuous cometary atmospheres. Geology/geophysics research will be directed at specific problems in understanding the various processes that have shaped planetary surfaces, as well as geological analyses and a cartography effort based on the Galilean, Saturnian and Uranian satellite imaging data acquired by Voyager. Analysis of lunar samples, meteorites, and extraterrestrial dust particles will be continued in FY 1989 to determine their chemical and physical properties and thereby derive their origin and evolutionary history. Instrument definition activities will continue to support development of new state-of-the-art instruments with emphasis on those supporting a future mission to Saturn and its moon Titan and for a Cosmic Dust Collection Facility planned as an attached payload for the Space Station. The Mars Data Analysis Program will support continued analysis of Mars data in preparation for new Mars missions and for continued development of the Planetary Data System to archive all planetary data for enhanced accessibility for all users. Within Advanced Programs, advanced technology development for potential future missions will also be continued with emphasis on the Mariner Mark II spacecraft.

The FY 1989 Halley's Comet Co-Investigations and Watch funding is required to continue support of U.S. co-investigators, who will be analyzing and archiving the data acquired during ESA's Giotto mission encounter with Halley's Comet. International Halley Watch funding will support the archiving and distribution of ground-based observations.

The FY 1989 funding will also provide for continued operations of both the Infrared Telescope Facility in Hawaii and the Lunar Curatorial Facility in Houston, Texas.

Planetary Exploration—Committee Comments

The Committee authorizes $399 million for Planetary Exploration in FY 1989. This reflects a general reduction of $5 million to the President's budget request.

The Committee is deeply committed to a robust space science program and believes that the launch of our Nation's planetary spacecraft will greatly rejuvenate our space science program. The fact that two of the Planetary Exploration Program's spacecraft, Galileo and Ulysses, were both prepared for launch in May 1986 and are now scheduled for launch in November of 1989 and 1990, respectively, is indicative of the setbacks suffered by space science. In light of these facts, the Committee has strongly endorsed NASA's FY 1989 budget request and program mix. Except for a general reduction of $5 million, the Committee has met the FY 1989 budget request despite severe budget pressures.

The Committee looks forward to the launches of the Magellan mission to Venus on the space shuttle in April 1989, and the Galileo mission to Jupiter on the space shuttle in November 1989. The Committee also anxiously awaits the Voyager/Neptune encounter in August, 1989.

However, the Committee is concerned with reports that NASA may be required to descope the instruments for the Mars Observer Mission because of technical problems in the development phase. The fact that similar problems have surfaced in other programs recently—ACTS and the GOES meteorological satellite—is cause for serious concern. The Committee expects to be advised formally of any problems in this program as soon as they occur in order to prevent unnecessary cost escalations or schedule delays.

At this point, the Committee also should indicate that pursuant to the availability of funds, it has authorized the procurement of a Titan III for the Mars Observer Mission and has authorized initiation of the procurement of a Titan IV planetary backup. As is noted in the Committee Comments for Expendable Launch Vehicles, the Committee has partially funded the Titan IV.

The Committee believes that the Mars Observer mission is an important space science mission that has important foreign policy implications. The current degree of interaction and data sharing between the United States and Soviet Union, both of whom have aggressive Mars Missions planned, points to the potential benefits of international cooperation in space. Despite these recent advances, the Committee does not yet believe the conditions exist—political, budgetary or foreign policy—to support initiation of a joint U.S./U.S.S.R. Mars program leading to support a cooperative manned mission to Mars. The Committee does look most favorably at on-going activities between the Unites States and the Soviet Union in the global change arena and towards furtherance of the April, 1987 Agreement Concerning Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes. And the Committee hopes these areas of mutual cooperation are broadened and expanded over the course of time. However, the Committee believes that many small steps are required over an extended period of time before the United States commits to a major space initiative with the Soviet Union.

Finally, committee members are hopeful that the FY 1990 NASA budget request will contain a new start request for the Comet Rendezvous Asteroid Flyby/Cassini Mission and that the final approved budget will be able to accommodate these two missions critical to the leadership position of the U.S. planetary science program.

4. Space Applications—$628,300,000

The Committee authorizes $628,300,000 for Space Applications—Solid Earth Observations, Environmental Observations, Materials Processing in Space, Communications and Information Systems—in FY 1989. This is $66 million more than the President's request.

Of this amount, $82,100,000 is for Solid Earth Observations; $358,300,000 is for Environmental Observations; $73,400,000 is for Materials Processing in Space, $92,200,000 is for Communications, and $22,300,000 is for Informations Systems. However, a general reduction of $10 million must be absorbed by these accounts at NASA's discretion.

A. SOLID EARTH OBSERVATIONS—$82,100,000

The Committee authorizes $82,100,000 for Solid Earth Observations in FY 1989. This is the same as the President's request. However, this account could be required to absorb part of the $10 million general reduction to the Space Applications account.

Summary of FY 1989 funding levels

Payload and Instrument Development	$25,300,000
Geodynamics	33,900,000

Research and Analysis	22,900,000
Total Solid Earth Observations	[1] 82,100,000

[1] Could be required to absorb part of $10 million general reduction to the Space Applications account.

The objectives of the Solid Earth Observations program are to understand the processes controlling the state of the land-surface and the interior of the Earth, as well as the interaction of the solid Earth with the atmosphere and the oceans. The Solid Earth Observations Program is an integral part of the overall NASA Earth Science and Applications effort to increase understanding of the planet Earth through the study of its dynamics, the physical processes which affect habitability, and solar-terrestrial environment.

The major objectives of the Solid Earth Research and Analysis program are to characterize the current state of the terrestrial landscape, including the biosphere and hydrosphere, and the changes and change mechanisms that are occurring within that landscape. Studies of the cycling of key biogeochemical elements, interactions between the biosphere and the climate system, the composition and evolutioin of the Earth's crust and the processes that shape the Earth's crust are essential to these objectives.

The geodynmics research objectives include determination of the movements and deformation of the Earth's crust, the processess which drive tectonic plates, the rotational dynamics of the Earth and its interactions with the atmosphere and oceans, the Earth's gravity and magnetic fields, and the interior structure and composition of the Earth. These objectives require precise measurements of crustal movements and Earth orientation over an extended period along with accurate knowledge of the Earth's geopotential fields and their variability.

The objective of the Shuttle/Spacelab payload development program is to develop, test and evaluate Earth-viewing remote sensing instruments and systems to obtain data for solid earth observations research. The Shuttle Imaging Radar–B (SIR–B), which was flown on the Shuttle in October 1984, has demonstrated the utility of spaceborne imaging radar for geopolitical exploration. The Large Format Camera (LFC), required for high resolution mapping applications, was flown successfully on the Shuttle in 1984 and is presently under consideration for commercialization. The next generation Shuttle Imaging Radar (SIR–C), which involves the use of SIR–B components, is a multi-polarized, dual frequency instrument under development for flight in 1991. The imaging spectrometer and solid-state sensor research efforts will continue to focus on the development of such features as electronic scan, inherent geometric and spectral registration and programmable high spatial and spectral resolution.

Payload and Instrument Development

The objective of this program is to develop, test, and evaluate Earth-viewing remote sensing instruments and systems to obtain data for and to develop the techniques for land remote sensing research.

Components of the SIR–B will be used in building the next generation Imaging Radar instrument, SIR–C. The SIR–C will use multi-polarized, dual frequency sensor technology. SIR–C is in the development phase; System Requirements Review, Antenna Preliminary Design Review and System Preliminary Design Review are complete. In October 1987, NASA signed a Memorandum of Understanding with the Federal Republic of West Germany agreeing to joint missions of SIR–C with an X-band imaging radar to be provided by a joint German/Italian project (X–SAR). Preparations continue for commercialization of the LFC.

Advanced spectrometer technology development activities include fundamental research in remote sensing involving airborne and spaceborne imaging spectrometer instruments. The imaging spectrometer and liner array solid-state sensor research focuses on the development of such features as inherent geometric and spectral registration and programmable high spatial and spectral resolution. The critical technology development and supporting research on the Shuttle Imaging Spectormeter Experiment (SISEX) and the linear array focal plan will continue.

Funding for FY 1989 is required for continued development of SIR–C technology, and for advanced spectrometer activities including the development of the SISEX.

Geodynamics

The objective of the Geodynamics program is to understand the origin, evolution, and current state of the solid Earth by measuring the movement and deformation of the tectonic plates and by measuring its rotational dynamics and potential fields. Laser ranging to satellites and the moon, microwave interferometry using astronomical radio sources and transmissions from the Global Positioning Satellite System (GPS) are used to determine precise position locations. The global gravity and magnetic fields are determined from satellite observations.

Measurements over the past years have provided experimental determination of the velocities of several of the major tectonic plates. Measurements of regional deformation across the San Andreas Fault continue to indicate a relative movement of the Pacific and North American Plate of about six cm per year. In addition, measurements indicate that about four cm of this movement is occurring in Southern California.

In FY 1989, measurements of plate motion between North America and Europe will be continued in cooperation with countries in Europe, Middle East, Far East, South, and Central America. Measurements of the motions of the Pacific Plate will be continued in cooperation with Japan and China. Regional crustal deformation measurements in western North America will continue in cooperation with The National Oceanic and Atmospheric Administration (NOAA), Canada and Mexico. The Caribbean studies will be continued and include more sites along the plate boundary and on the plate itself.

LAGEOS–1 (Laser Geodynamics Satellite) and other satellites will continue to be used for studies of plate motion. NASA systems in the United States, Pacific, South America, and Australia will be operated in cooperation with laser systems in 12 other countries. The LAGEOS–2, a joint mission with Italy, is presently under development by Italy and will be launched by the United States on the Space Shuttle in 1991.

Theoretical studies of crustal motion, internal Earth structure and composition, and the modeling and interpretation of geopotential fields will be continued in FY 1989. In addition, system studies of a second magnetic field satellite for long-term measurements of the Earth's field (Magnolia/MFE), studies of geopotential research, and laboratory development of room-temperature and cryogenic gravity gradiometer instrumentation will continue.

Research and Analysis

The research and analysis program has four main elements and four main goals. The broad goal of the Biogeochemical Processes program is to achieve an improved understanding of the role of terrestrial biota in processes of global significance through the use of airborne and spaceborne sensors. The goals of the Hydrology program are to use remote sensing to achieve a better understanding of the regional and global storages and fluxes of the land component of the Earth's hydrologic cycle, to investigate the role of the hydrologic cycle in regional and global biogeochemistry, and to examine the interactions between land surface processes and regional and global climate.

The goal of the Geology program element is to derive a better understanding of the Earth's geology, geological history, and the processes that have shaped the surface of the Earth over geological time using spaceborne sensors. The Remote Sensing Science program's goal is a crosscutting activity which supports the three other disciplinary program elements through theoretical modeling and field measurements of land surface properties.

In FY 1989 emphasis will be on investigations using multiple sensors operating in the visible, near-infrared, shortwave infrared, thermal infrared, and the microwave. Advanced airborne instruments which are prototypes for the future Earth Observing System (EOS) will be used in a variety of geologic, ecological and hydrological experiments. The theoretical basis for the use of combined sensors will be developed within the Remote Sensing Science program element. Current theoretical models will be used in the design of these experiments which will be designed to meet specific scientific goals in the other program elements.

As a part of NASA's program for the study of Global Change, there will be a series of multitemporal ecosystems studies using the airborne prototypes of EOS instruments. Vegetation is dynamic over a growing season, and remote sensing coverage at an instant in time only captures one stage of the annual cycle. Repetitive coverage of selected sites offers the opportunity to study dynamic, and not just static, properties of ecosystems. NASA plans to select a small number of sites to be scheduled for multiple data acquisition spanning the growing season and to encourage several investigators to conduct investigations at any one site.

The two board goals of the Geology program expressed above will be addressed through focused efforts which will be idendified in workshops to be held during 1988. These are expected in the fields of volcanism (volcanic processes, monitoring, and hazard identification/prevention), quaternary land climatologic history, and neotectonics of actively faulting areas.

Operational satellite systems will be used in conjunction with the advanced airborne sensors. Multiyear data sets from the Landsat Multispectral Scanner, the Advanced Very High Resolution Radiometer (AVHRR) and the Scanning Multifrequency Microwave Radiometer (SMMR) will be used to study global change on the decadal scale. Global data sets will be maintained using the AVHRR and the Special Sensor Microwave Imager (SSMI), which replaces the SMMR.

The initial phase of the International Satellite Land Surface Climatology Project's (ISLSCP) First ISLSCP Field Experiment (FIFE) will be completed. Guest investigators will be supported to broaden the base of users of this comprehensive data set, and mechanisms will be established to make the data available to other investigators.

Solid Earth Observations—Committee Comments

The Committee authorizes $82,100,000 for Solid Earth Observations in FY 1989. This is the same as the President's budget request. However, NASA may apply to this account a portion of the $10 million general reduction to Space Applications.

The Committee continues to believe that there is compelling scientific need to increase U.S. access to and utilization of multiple sources of remotely sensed data. This is especially true in light of the increased interest in Global Change issues. The Committee, therefore, is pleased that NASA, NOAA, the National Science Foundation (NSF), and the U.S. Geological Survey have agreed to participate in an Interagency Working Group on Data Management for Global Change. This Working Group should play a significant role in building a national data and information system for global change research which is consistent across agencies and involves and supports the university and other user communities. The Committee believes that this initiation should provide a vital link to other sources of remotely sensed data, and the Committee expects to be informed of significant developments related to this initiative.

Meanwhile, NASA should continue its activities to develop, test and evaluate Earth-viewing remote sensing activities, in particular the SIR–B.

As noted above, there is a growing interest in global change issues. The Committee, therefore, intends to work closely with NASA and other involved Federal agencies in the formulation of a National Global Change Research Plan that results in a well-defined, orderly global change research program.

B. ENVIRONMENTAL OBSERVATIONS—$368,300,000

The Committee authorizes $368,000,000 for Environmental Observations in FY 1989. This is the same as the President's request. However, this account could be required to absorb part of the $10 million general reduction to the Space Applications account.

Summary of FY 1989 funding levels

Upper Atmosphere Research and Analysis	$34,000,000
Atmospheric Dynamics and Radiation Research and Analysis	32,800,000
Oceanic Processes Research and Analysis	21,600,000
Payload and Instrument Development	19,700,000
Mission Operations and Data Analysis	18,500,000
Interdisciplinary Research and Analysis	1,200,000
Scatterometer	15,800,000
Upper Atmosphere Research Satellite Program	103,900,000
Ocean Topography Experiment	97,800,000
Airborne Science and Applications	23,000,000
Total Environmental Observations	[1] $368,300,000

[1] Could be required to absorb part of $10 million general reduction to the Space Applications account.

The objectives of the Environmental Observations program are to improve our understanding of the processes in the atmosphere and the oceans; to provide space observations of parameters involved in these processes; and to extend the national capabilities to predict environmental phenomena, both short- and long-term, and their interaction with human activities. Because many of these phenomena are global or regional, they can be most effectively, and sometimes only, observed from space. NASA's programs include scientific research efforts plus the development of new technology for global and synoptic measurements. NASA's research satellites provide a unique view of the radiative, chemical, and dynamic processes occurring in the atmosphere and oceans.

To achieve these goals, a number of significant objectives have been established for the next decade. These include advancing the understanding of the upper atmosphere through the determination of the spatial and temporal distribution of ozone and select nitrogen, hydrogen, and chlorine species in the upper atmosphere and their sources in the lower atmosphere; optimizing the use of space-derived measurements in understanding large-scale weather patterns; advancing our knowledge of severe storms and forecasting capabilities, ocean productivity, circulation, and air-sea interactions; and improving the knowledge of seasonal climate variability leading to a long-term strategy for climate observation and prediction.

Effective utilization of remote sensing requires a balanced set of activities including: analytical modeling and simulation; laboratory research of fundamental processes; development of instrumentation; flight of the instruments on the Space Shuttle, dedicated spacecraft and flights of opportunity; collection of *in situ* ancillary or validation data; and scientific analysis of data. The approach is to develop a technological capability with a strong scientific base and then to collect appropriate data, through remote and *in situ* means, which will address specific program objectives.

The Upper Atmospheric Research Satellite (UARS) will place a set of instruments in Eargh orbit which will make comprehensive measurements of the state of the stratosphere, providing data about the Earth's upper atmosphere in spatial and temporal dimensions which are presently unattainable.

Detailed definition studies of the instruments have been completed, and the design and development activities are well under way.

Development of the UARS observatory will continue in FY 1989, consistent with a planned launch in 1991.

The Earth Radiation Budget Satellite (ERBS) was successfully launched in 1984, and data continues to be collected from the satellite. NOAA-F was launched December 12, 1984, and NOAA-G was launched September 17, 1986, both equipped with Earth Radiation Budget Experiment instrumentation. NASA is also continuing to support NOAA by managing the implementation of the polar orbiting NOAA and Geostationary Operational Environmental Satellites (GOES) series on a reimbursable basis.

Design and development activities are being continued in FY 1989 on the NASA Scatterometer (NSCAT), the objective of which is to acquire global ocean data for operational and research use by both military and civil sectors. While the U.S. Navy reviews the possible continuation of the Navy Remote Ocean Sensing System (N-ROSS) program, Scatterometer instrument development continues along with planning for alternative spacecraft flight opportunities.

Development of the Ocean Topography Experiment (TOPEX) began in FY 1987 and will continue in FY 1989. Its objective is to acquire precise observations of the surface topography of the oceans. These data, in conjunction with those from NSCAT, will enable the first determination of the wind forcing and ocean current resposne of the global oceans. Spacecraft development efforts have begun at Fairchild, while the Johns Hopkins Applied Physics Laboratory continues work on TOPEX Altimeter development.

The Nimbus spacecraft continues to collect unique data which is being used in the study of long-term trends of the Earth's atmosphere, oceans and polar ice, and provides near real time data. Collection and analysis of Solar Mesosphere Explorer (SME) data, the only mesosphere data currently available, continues.

Shuttle payload and instrument development activities provide the airborne and spaceborne data necessary to conduct basic research projects as well as provide correlative and developmental feasibility information for major free-flying spacecraft. Instrument activities include Shuttle payloads such as Atmosphere Trace Molecules Observed by Spectroscopy (ATMOS), Active Cavity Radiometer (ACR), and Light Detection and Ranging (LIDAR).

Along with the Solid Earth Observations program, the Environmental Observations activities compose an integral part of NASA's total Earth sciences and applications efforts, with emphasis on understanding the Earth as a planet, studying its dynamics, processes, habitability, and solar-terrestrial environment.

Elements of the Mission Operations and Data Analysis Program and the Payload and Instrument Development Program as well as the entire Tether Satellite Payloads, Space Physics Research and Analysis, and Global Geospace Science programs have been transferred to Physics and Astonomy in the recent OSSA reorganization and creation of the Space Physics Divison.

Upper Atmosphere Research and Analysis

The upper atmosphere research program is a comprehensive research and technology effort designed to investigate and monitor the phenomena of the upper atmosphere and related phenomena in the lower atmosphere. It is aimed at improving our basic scientific understanding of the global atmosphere and the methods needed to assess its susceptibility to significant chemical and physical change. The program's three major thrusts are in the areas of upper atmospheric research, stratospheric processes research, and tropospheric chemistry research.

In particular, the goal of the upper atmosphere research program is to understand the physics, chemistry and transport processes in the stratosphere on a global scale, and to assess as accurately as possible the perturbations to the atmosphere caused by man's activities.

A variety of *in situ* and remote sensing techniques are needed to meet the objectives of determining and understanding the distribution of ozone and other trace species in the atmosphere. Data sets from a limited number of satellites are now generally available to the scientific community, including a record of the global distribution of ozone extending back over a decade, and simultaneous observations of a number of trace constituents. This data is being exploited to determine if trends in the ozone amount can be detected and to understand those processes which are directly involved with these trends.

Recent developments in our understanding of the ozone layer have revealed a possible non-linear dependence of ozone depletion on the amount of fluorocarbon released to the atmosphere. These findings place increased urgency on the need to verify the completeness and accuracy of the theoretical stratospheric models. In FY 1989, tests of the models will be continued by means of field measurements, model calculations, and interpretation of satellite data. The development of more realistic two- and three-dimensional models will be continued. The global data sets from past and present satellites will be further analyzed in FY 1989 to aid in the understanding of large-scale atmospheric processes.

The comparison of balloon, aircraft, and ground-based measurements will be continued in FY 1989 to ensure the validity of the different techniques that have been developed and to observe chemical species in the stratosphere and troposphere to determine the exchange of gases between the lower and upper atmosphere. These balloon and aircraft measurement programs are the only way to measure many of the localized phenomena of the atmosphere; they also help to validate satellite observations. Studies of potential new instruments for use on future satellites and suborbital measurement platforms will also be conducted in FY 1989 to ensure that new technologies are put to use in improving the capability and cost efficiency of tropospheric compositon and upper atmosphere measurements.

The recent observations of a depletion in the amount of ozone over Antarctica in the austral spring have attracted a great deal of attention. In order to understand the chemical and dynamic processes that are causing this phenomena, a major aircraft mission conducted in late FY 1987–early FY 1988 using NASA ER–2 and DC–8. Analysis and interpretation of the results of this mission will be a critical effort in FY 1988. An Arctic and/or return Antarctic mission is planned for FY 1989 based on the results of the 1987 campaign.

Atmosphere Dynamics and Radiation Research and Analysis

The research and analysis activities within the Atmospheric Dynamics and Radiation program combine a core effort which is essential in order to use space technology to address problems in atmospheric sciencies. The three main thrusts in the program are in the areas of Global-Scale Processes, Mesoscale Processes and Climate Research.

The objectives of the global-scale research program are to improve our understanding of large-scale atmospheric behavior and to develop improved capabilities to observe the atmosphere from space.

The objectives of the mesoscale processes research program are to improve our understanding of the behavior of the atmosphere on short (minutes to hours) time scales and local to regional scales (severe weather, such as tornadoes and hurricanes). Since all of the characteristic parameters of these mesoscale processes cannot be measured directly, new techniques are under study to derive the information from other observations which can be directly measured.

Finally, the Climate Research Program seeks to develop a space capability for global observations of climate parameters to increase our understanding of the process that influence climate and its predictability. In accordance with the National Climate Program priority, research in solar and Earth radiation is led by NASA.

A significant research effort to develop the capability for observing rainfall from space continues. Studies of instruments, sampling requirements, algorithm development, and modeling indicate the feasibility of sensing rainfall from space for climatic purposes. Under a bilateral agreement with the Science and Technology Agency of Japan, NASA is cooperating in a joint study of a special mission to measure tropical rainfall. Studies to accommodate a rainfall measurement experiment on the Space Station have been initiated and will be continued.

Funding for FY 1959 is required for support of the Global Backscatter Experiment (GLOBE). Two field campaigns are scheduled in GLOBE using the NASA DC–8. These airborne observations and the auxiliary observations to be made from ground-based and satellite observatories will be used to determine the seasonal and geographic variations in the backscatter of laser radiation due to atmospheric aerosols. In addition to increasing our understanding of the optical properties of the atmosphere, these data are needed in the system design of the Laser Atmospheric Wind Sounder (LAWS), a facility instrument for the future EOS.

An initiative in Radiative Gas Effects is being planned as a potential new focus for the Climate Research program during FY 1989. In particular, plans for the detection of greenhouse effect on climate from space observations will be pursued.

Funding for FY 1989 also is required to provide instruments and support for aircraft flights to study the detail of flows around thunderstorms and weather fronts, continue development and comparison of numerical models, study atmospheric scale interactions, and develop techniques to display model outputs in four-dimensions. Continued analysis of the data collected in interagency field experiments during FY 1986 and 1987 will be performed. In addition, experimental, theoretical, and computational work will be done to better define the capabilities and requirements for the remote measurement of rainfall; and preliminary planning, experiment design, and technology development will begin for the large, multiagency STORM program to evaluate the research and operations potential of new meteorological remote sensors such as the sounder on GOES-NEXT, NEXRAD, AWIPS-90, ASOS, SSM-I, AVHRR-3 and high-altitude active and passive sensors to estimate precipitation.

Oceanic Processes Research and Analysis

The Oceanic Processes Research and Analysis (R&A) program emphasizes the development and application of spaceborne observing techniques to advance our understanding of the fundamental behavior of the oceans, as well as to assist users with the implementation of operational systems.

The Oceanic Processes R&A program is organized into three discipline areas: (1) physical, (2) biological, and (3) polar oceanography. In physical oceanography, satellite scatterometers and altimeters are used to observe surface roughness and topography, from which surface winds and ocean current response can be estimated. In biological oceanography, color scanners are used to observe chlorophyll concentration, from which primary productivity can be estimated. In polar oceanography, microwave radiometers and synthetic aperture radars are used to estimate the characteristics of sea-ice cover and the details of its motion.

The Oceanic Process R&A program operates in concert with other federal agencies (Navy, NOAA, and NSF) and foreign countries (Canada, Europe, and Japan) for the World Climate Research Program (WCRP). Component WCRP efforts include the Tropical Ocean/Global Atmosphere (TOGA) and World Ocean Circulation Experiments (WOCE), a Global Ocean Flux Study (GOFS) and a Program for International Polar Oceans Research (PIPOR).

In FY 1989, the physical oceanography research activities will include implementation planning for WOCE and TOGA, as well as the development of assimilation techniques to incorporate altimeter and Scatterometer data into numercial models for use in determining the general circulation of the oceans. In biological oceanography, global ocean productivity will be assessed based on analyses of Nimbus-7 Coastal Zone Color Scanner (CZCS) data, in order to help with the conceptual design of the Global Ocean Flux Study. In addition, implementation studies will be performed with EOSAT for potential flight of an ocean-oriented color scanner (Sea WIFS) aboard the Landsat-6 spacecraft. In polar oceanography, emphasis will be placed on the experimental design for PIPOR, which is planned to involve direct reception at the Alaska Synthetic Aperture Radar (SAR) Facility in Fairbanks of SAR data from the ESA ERS-1 (Earth Resources Satellite) and from the Japanese Earth Resources Satellite (JERS)-1 spacecraft, due for launch in 1990 and 1992, respectively.

Significant work on the NASA Ocean Data System will be performed in order to optimize its use as a scientific support facility for the ocean research community. NASA's activities are being coordinated with the Office of Naval Research, NSF, and NOAA in order to assure that appropriate computing facilities, data archives, and communication networks will be available for the utilization of spaceborne observations from missions, planned within the next decade.

Payload and Instrument Development

The Space Transportation System offers the unique opportunity for short-duration flights of instruments. The Environmental Observations program has incorporated this capability into the Shuttle/Spacelab payload development activities in these important aspects: early test, checkout and design of remote sensing instruments for long duration free-flying missions; and short-term atmospheric and environmental data gathering for basic research and analysis where long-term observations are impractical. Instrument development activities support a wide range of instrumentation—from airborne to international flights of opportunity.

Funds for 1989 will be used to support the Measurement of Air Pollution from Satellites (MAPS) science team activities including data reduction, refurbishment for reflight and upgrading of the ground services equipment. The FY 1989 funding for ATMOS is required to support the ground observation program as well as continued science team activities, data processing and analysis, and limited refurishments. FY 1989 funding is also required to continue the ACR data processing, science team activities, and refurbishment for reflight on future Shuttle ATLAS flights, and development of a free-flyer version of ACR.

Preliminary definition on the advanced instrumentation and data facilities associated with the future EOS will be continued in FY 1989. The EOS is the intended payload on the Space Station's polar platform. Instrument definition and feasbility studies will be continued along will related system engineering and payload accommodation studies. Release of an Announcement of Opportunity to the Scientific Community is presently planned for FY 1988. Further detailed review of those proposals will be conducted in FY 1989.

Development activities will continue on the international (United States and France) (LIDAR) airborne instrumentation following completion of critical design reviews in preparation for the integration, ground test and first flight in FY 1989 of this multi-phase user program. In this program, both NASA and the French are supplying scientific knowledge and hardware to demonstrate first-time detail measurements of the atmosphere to aid in forecasting.

Mission Operations and Data Analysis

The objective of the extended mission operations program is to provide for the operations, data processing, validation and data analysis of missions which have completed basic operations funded by approved project support.

Operation of the Nimbus and SME satellites and processing of the collected data will be continued as will activities to provide ground truth for a NASA-developed ozone instrument to be flown on a NOAA meterological satellite. The SME and Nimbus satellites continue to produce extremely valuable data on ozone concentrations which will be used to estimate the occurrence of natural and man-made variations, sea surface temperatures, aerosol measurements, and ocean productivity. Correlative ground truth activities will also be continued in FY 1989; these *in situ* observations are needed to verify the quality of remote observations and improve the ability to interpret them.

In addition, FY 1989 funding is required for operating the ERBS spacecraft and for data processing and analysis from the total three-instrument system, and from the SAGE-II instrument of ERBS.

Interdisciplinary Research and Analysis

Interdisciplinary research activities need to be conducted to quantitatively characterize the Earth's chemical, physical, and biological processes on the land, along with the interactions between the land, the oceans, and atmosphere, which are of particular importance in assessing the impact of these phenomena on global, physical, and biogeochemical processes. Such research is essential to investigating and assessing long-term physical, chemical, and biological trends and changes in the Earth's environment. Included in the program activities are joint efforts from a variety of disciplines, including atmospheric science, climatology, biological sciences, geochemistry, and oceanography.

In FY 1989, interdisciplinary studies will be continued with emphasis on integrating discipline-specific research activities of Oceanic Processes, Atmospheric Dynamics and Radiation, Upper Atmosphere/Troposphere Chemistry, and Land Processes into a unified program which will help increase our understanding of critical global processes. Emphasis will be placed on specific pilot studies such as those understanding the biogeochemical processes controlling the concentration of atmospheric methane, characterizing changes in properties of the land surface and their effect on climate, and understanding the role of the ocenas in the global carbon cycle.

Scatterometer

The NSCAT will provide accurate, global measurements of ocean surface winds which will be useful for both oceanography and meteorology. In addition to providing wind field data, Scatterometer data will permit the first global study of the influence of winds on ocean circulation, provide data on the effects of the oceans on the atmosphere, and provide improved marine forecasting (winds and waves). Flight of the instrument in 1992 for three years will provide an overlap of data gathering with the World Ocean Circulation Experiment, Tropical Ocean-Global Atmospheres Experiment planned by the international oceanographic community; and additionally, concurrent flight with TOPEX would result in unique measurements of the ocean's driving force (winds) and the resulting ocean response (topography).

The Scatterometer was designed to fly on the N-ROSS satellite in 1992. The N-ROSS program was cancelled in December 1986 due to financial constraints, but a lower cost version of N-ROSS was proposed by the Navy for reinstatement in April 1987. Unfortunately, after review by DOD, no funds were included in the FY

1989 DOD budget request for N-ROSS. In the meantime, NASA has been exploring a number of alternatives to N-ROSS, the most cost-effective of which will be selected for implementation.

During FY 1988, the antenna contract will be completed, and all six flight antennas will be finished. The Traveling Wave Tube (TWT) contract is scheduled to be completed, and the development of the other flight hardward items will be continued. The instrument Critical Design Review, which was delayed due to the N-ROSS cancellation, will be held, and delivery of the second computer system for the ground data system will occur.

Planned activities in FY 1989 include the continuation of flight hardward development leading to the beginning of flight unit integration and testing at the end of the fiscal year; the completion of software requirements definition; the initiation of detailed software design, both for the ground data and flight systems; conducting the PDR for the mission operation system; and confirmation of the science team which was delayed due to the uncertainty of N-ROSS.

Upper Atmosphere Research Satellite Program

The UARS program is the next logical step in conducting a comprehensive program of research, technology development and monitoring of the upper atmosphere aimed at improving basic scientific understanding. This mission, scheduled for a STS launch in 1991, is essential for understanding the key radiative, chemical and dynamical processes which couple together to control the composition and structure of the stratosphere. The UARS mission will provide the first intergrated global measurements of: ozone concentration; chemical species that affect ozone; energy inputs; temperature; and winds in the stratosphere and mesosphere.

The FY 1989 funds are required for continuation of the development activities on the ten UARS instruments including flight hardware fabrication, instrument assembly and environment testing, leading to instrument delivery to the spacecraft in 1989. The spacecraft development and hardware fabrication activities will continue, including completion of the spacecraft mechanical test model program and the start of spacecraft integration and test in late FY 1988.

The ground data handling facility will enable a higher level of interaction among experimenters and theoreticians than has existed with past programs. Implementation of this concept requires that the system be developed on a timely parallel path with the flight hardware so that individual experiment data processing subsystems, including algorithms and the interactive data base, provide maximum interaction and effectiveness in the design and development phase of the program and are fully verified at launch time. In order to achieve this, FY 1989 funding is required to continue design and development of the ground data handling facility including hardware delivery and checkout, software preliminary and critical design reviews, science team support and science algorithm development.

Ocean Topography Experiment

The goal of this program, TOPEX, is to utilize satellite radar altimetry to measure the surface topography of the global oceans over a period of three years with sufficient accuracy and precision to significantly enhance our understanding of the oceans' general circulation and its mesoscale variability.

NASA and the French Space Agency (CNES) are collaborating on TOPEX in order to more fully exploit the scientific value of the data. In exchange for this scientific collaboration and the flight of a French altimeter and tracking system, CNES will launch TOPEX in late 1991 using Ariane. TOPEX is also being planned in concert with WOCE, a major international oceanographic field program being planned under the auspices of WCRP.

In FY 1989, the design of the satellite, sensor, and ground data system will be completed, leading to the initiation of full-scale spacecraft system development. Final arrangements are expected to be made by CNES for the French-provided Ariane launch vehicle; the mission design will be refined based on input from and interaction with the Science Team; and the Science Team will be confirmed so that they can begin to refine their post-launch research and verification plans.

Airborne Science and Applications

This effort covers operation of an ER-2, two U-2C's, a C-130, and a DC-8 in order to support Earth-sensing and atmospheric research. The DC-8 was acquired to replace the CV-990 research facility, "Galileo II," which was destroyed in 1985. The replacement DC-8 has undergone required upgrades and modifications and carried out initial operations in Antarctica in 1987 as part of the Ozone Hole campaign. Acquisition of a second ER-2, to replace the aging U-2C's is under way. These aircraft support other major segments of the Space Science and Applications program dealing with the Earth, the oceans, and the atmosphere.

Requested FY 1989 funding will allow operation of the DC-8, two ER-2's, and the C-130. Operation of the aircraft will allow continuation of such projects as the collection and analysis of stratospheric air samples, testing of newly developed instrumentation, the demonstration of new sensor concepts, the investigation of the Ozone Hole phenomena, and participation in numerous other field experiments, such as First International Satellite Cloud Climatology Project (ISCCP) Regional Experiment (FIRE). The FY 1989 budget will also provide for NASA's final payment to the U.S. Air Force, thereby completing the purchase of the second ER-2 aircraft.

Environmental Observations—Committee Comments

The Committee authorizes $368,300,000 for Environmental Observations in FY 1989. This is the same as the President's budget request. However, NASA may apply to this account a portion of the $10 million general reduction to Space Applications.

The Committee notes that the interest in Global Change, highlighted in the Committee Comments for the Solid Earth Observations, is further solidified in this account that supports the development of ocean/atmospheric spacecraft, advanced instruments, and aircraft observations. At the outset, the Committee applauds the members of the NASA research teams who participated in the Antarctica Ozone Hole Campaign last year and who supported the U.S.

delegation to the Montreal Protocol Talks concerning chlorofloro-carbons.

The Committee reiterates its support of the Upper Atmospheric Research Satellite program—this mission will provide the first integrated global measurements of ozone concentration and chemical species that affect ozone—and the Ocean Topography Experiment. Both of these missions appear to be on schedule for launch in 1991 and should significantly improve our understanding of atmospheric and oceanic processes.

The Committee strongly supports the proposed enhancement in FY 1989 of the preliminary definition activities of the advanced instrumentation and data facilities of the EOS—the intended payload on the space station's polar platform.

The Committee is concerned that the Navy has once again terminated the N-ROSS and that currently there is no assigned spacecraft on which to fly the NSCAT. The Committee understands that discussions are under way with the government of Japan to fly the scatterometer on a Japanese spacecraft, and the Committee expects to be kept well-apprised of the situation. Meanwhile, the Committee recommends that NASA proceed with the development of the scatterometer and complete the hardware development as soon as possible.

Finally, committee members recommends that NAA earmark $10 million of the approved FY 1989 budget for Environmental Observations for Earth Probes—small-scale expendable satellites with focused science objectives that will result in the evolutionary development of earth science satellites.

C. MATERIALS PROCESSING—$73,400,000

The Committee authorizes $73,400,000 for Materials Processing in FY 1989. This is the same as the President's request. However, this account could be required to absorb part of the $10 million general reduction to the Space Applications account.

Summary of FY 1989 funding levels

Research and Analysis	$13,600,000
Microgravity Shuttle/Space Station Payloads	59,800,000
Total Materials Processing	[1] $73,400,000

[1] Could be required to absorb part of $10 million general reduction to the Space Applications account.

The mission of the Microgravity Science and Applications Program is to foster the development of near-earth space as a natural resource by exploiting microgravity and other unique attributes that may be attained in an orbiting spacecraft. In this environment we can advance knowledge about the fundamental nature of matter, increase understanding of the role of gravity in various industrial processes, and produce limited quantities of certain exotic high value materials for specialized applications. In FY 1989, ground-based research and payload development will be concentrated in six major areas: metals and alloys, electronic materials, glass and ceramics, biotechnology, combustion, and fluid dynamics and transport phenomena.

During FY 1989, ground-based research will support definition studies for Shuttle and Space Station experiment candidates in areas such as containerless experiments, solidfication and crystal growth, and processing of biological materials. Researchers will conduct experiments in drop tubes, towers and aircraft. The ground-based research program also includes support for studies conducted under Technical Exchange Agreements.

The Microgravity Shuttle/Spacelab Payloads program provides a range of experimental capabilities for all participants in the Materials Processing in Space program. The payloads program currently supports a wide variety of hardware development, from unique flight experiments necessary to conduct basic research into the fundamental nature of matter to the modular, multi-user research facilities that will be the cornerstone of microgravity science and applications research on the Space Station. Experiments will be flown on Shuttle and Spacelab, as well as any promising commercial space facility.

Research an Analysis (Materials Processing)

The research and analysis activity provides the scientific foundation for all current and future projects in the Microgravity Science and Applications program. Emphasis is placed on ground-based research which is expected to evolve into space investigations with potential for future applications. This activity also supports technology development for future ground and space capabilities and applications activities leading toward privately funded space enterprises. Most research projects are initiated as a result of proposals from the scientific community which have been extensively reviewed by peer groups prior to selection.

Ground-based research and analysis will be continued in FY 1989 in the areas of metals and alloys, electronic materials, glass and ceramics, biotechnology, combustion, and fluid dynamics and transport phenomena. Research will be conducted to define the role of gravity-driven influences in generic processing methods. Effort will continue at the centers for bioprocessing research located at the University of Arizona and the University City Science Center in Philadelphia, PA. as well as the Microgravity Materials Science Lab at the Lewis Research Center.

Microgravity Shuttle/Space Station Payloads

The Mocrogravity Shuttle/Space Station payloads program provides a wide range of opportunities for experiments in microgravity science and applications. NASA currently supports the development of STS mid-deck, Spacelab and cargo-bay experiments. This policy maximizes the effective use of the STS by matching an experiment with the hardware location best suited to meet its scientific and technical requirements. In some cases, the payload program supports an evolutionary program of testing flight experiment concepts in the mid-deck before committing to more complex and ambitious Spacelab or cargo-bay mounted hardware.

The Materials Processing in Space program is preparing to use Space Station as a major platform for conducting microgravity research. During FY 1987, NASA received funds from Congress to begin technical definition of six major multi-user research facilities designed to take advantage of Space Station's unique capabilities. NASA's Microgravity Science and Applications Division (MSAD) is developing a strategy for orderly evolution of microgravity experiments from ground-based research to the Shuttle, and finally to Space Station. During FY 1988 and FY 1989, MSAD will continue Space Station hardware definition and will initiate equipment development for both the first U.S. Microgravity Laboratory Spacelab mission and any promising commercial microgravity facility.

In addition to the planned Space Station Initiative, the Materials Processing in Space program is placing increased emphasis on NASA's Physics and Chemistry Experiments (PACE) program, which uses microgravity research to challenge and improve existing scientific theory about the fundamental nature of matter. As other nations increase their ability to exploit the characteristics of near-Earth space, the "cutting edge" experiments generated by the PACE program will play an increasingly important role in assuring continued U.S. leadership in microgravity research.

Funding for FY 1989 is required to continue basic and applied research activities using STS mid-deck Spacelab and cargo-bay experiments leading to several flights over the next few years. Investigations are planned in fluid dynamics, glasses, electronic materials, biotechnology, metals and alloys, and combustion. Development will continue on a number of PACE initiatives as well as several pieces of advanced equipment in the areas of electronic crystal growth, biotechnology, metallic casting, and levitation. An augmentation has been included, building on the FY 1988 congressional increase, to develop the advanced second and third generation microgravity payloads which will be flown on the STS, Space Station, and any promising commercial space facility.

Materials Processing—Committee Comments

The Committee authorizes $73,400,000 for Materials Processing in FY 1989. This is the same as the President's budget request.

The Committee is most supportive of NASA's materials processing activities and believes that the long-term return from this program will be substantial. However, the Committee is concerned that if early unrealistic expectations for success are not met support for the program in later years could be affected.

As a result of the Committee's assessment of the proposed Commercially Developed Space Facility, the Committee has instructed NASA to contract with NAS to undertake a thorough and independent review of the Nation's microgravity research program and implementation plan. The Committee expects NASA to cooperate fully with this study and to provide all pertinent data.

The Committee is optimistic that as a result of this Academy study, which builds upon the findings and recommendations of NAS's recent report, "Industrial Applications of the Microgravity Environment," the Committee will be able to determine better the interim requirements for materials processing in space.

Meanwhile, the Committee continues to support the Materials Processing in Space program and will continue to work with NASA to maintain U.S. technological leadership in this critical area.

D. COMMUNICATIONS—$92,200,000

The Committee authorizes $92,200,000 for Communications in FY 1989. This is $76 million more than the President's budget request and reflects the Committee's strong support of the Advanced Communications Technology Satellite and the Nation's continued leadership in communications. However, this account could be required to absorb part of the $10 million general reduction to the Space Applications account.

Summary of FY 1989 funding level

Advanced Communications Technology Satellite (ACTS)	$76,000,000
Advanced Communications Research	10,486,000
Search and Rescue	1,350,000
Radio Science and Support Studies	2,900,000
Communications Data Analysis	1,464,000
Total Communications	[1] $92,200,000

[1] Could be required to absorb part of $10 million general reduction to the Space Applications account.

Advanced communications research continues to provide the development of subsystem component technology required by NASA, other government agencies, and U.S. industry for advanced communications satellite systems. Special emphasis is being given to pursuing technologies with high potential for improving spectrum and orbit utilization, satellite antennas, on-board processing intersatellite links and around terminal designs, since these technologies are the key to future growth of the communication satellite and terminal markets. In addition, the mobile communications technology program will continue to address the development of critical enabling technologies needed to insure growth of a commercial mobile satellite service in the United States. This effort, in cooperation with U.S. industry, Canada, and other government agencies, will help implement a first generation commercial system in the early 1990's.

The search and rescue program is an international cooperative program that demonstrates the use of satellite technology to detect and locate aircraft or vessels in distress. The United States, Canada, France, and the Soviet Union developed the system in which Norway, the United Kingdom, Bulgaria, Finland, and Denmark also participate.

Radio science and support studies, formerly technical consultation services, will provide for studies of radio interference, propagation and special systems required for the growth of existing satellite services and the extension of new satellite applications. Support to the Department of State, the Federal Communications Commission (FCC), the National Telecommunications and Information Administration, and other agencies in the development of frequency and orbit sharing techniques and strategies for upcoming World Administrative Radio Conferences (WARCS) is continuing.

Advanced Communications Research

The advanced communications research program emphasizes the development of high-risk technology required to maintain U.S. preeminence in the international satellite communications market, to enable new and innovative public services, and to meet the communications needs of NASA and of other government agencies.

In FY 1988, work is continuing on advanced communications technologies. Laser inter-satellite link communications technologies are being developed that will permit communications between satellites and ground terminals, satellites and low Earth orbiting vehicles, such as the Space Shuttle or Space Station, and between satellite and other geosynchronous orbiting satellites, such as the Tracking and Data Relay Satellite (TDRS). Technology development is also under way in the area of monolithic microwave integrated circuits (MMIC), which have significant potential for applications in multiport spacecraft matrix switches, low noise receivers, and multibeam antenna arrays and beam-forming networks. A number of industry studies are being sponsored to assess new areas of communications technologies required for the 1990's.

The mobile communications technologies activity is aimed at accelerating the introduction of a commercial mobile satellite service in the United States and developing and testing power, bandwidth and orbital-slot efficient ground segment technology and networking techniques needed to insure its growth. An innovative NASA offer to industry was signed in FY 1985 by a consortium of U.S. companies which would provide a launch for the first generation commercial satellite in exchange for satellite transponder capacity that would be used by NAS and other government agencies for experimentation and technology validation. The endeavor to commercialize this new service got a recent boost with the allocation of frequencies and the formation of a single consortium that is applying to the FCC for license approval. NASA is planning a major government/industry conference in May to exchange information and facilitate the transfer of technology to industry.

The Research and Analysis program will continue to support development of the technologies necessary for future space communications satellite systems. During FY 1989, NASA will continue to work with U.S. industry and other government agencies to complete field testing of advanced communications hardware and help accelerate the introduction of mobile satellite communications service in the United States. Work in laser communications technologies will be continued.

Search and Rescue

The United States (NASA, NOAA, the Coast Guard, the Air Force, and the Federal Aviation Administration), Canada, France, and the Soviet Union developed the search and rescue system in which Norway, the United Kingdom, Bulgaria, Finland and Denmark also participate. The Search and Rescue (SAR) satellite system was declared operational in July 1985. NOAA maintains operational responsibility for search and rescue, while NASA's role is tightly focused on the research and development aspects.

The SAR program, developed by NASA and international partners, has demonstrated the feasibility of using satellites to improve significantly the ability to detect and locate general aviation aircraft and marine vessels during emergencies. The system has received world-wide acclaim and has been credited with saving over 1,000 lives to date.

Funding in FY 1989 will continue the NASA unique research and development role in low-cost emergency beacon development, the next generation satellite-borne SAR equipment and advanced techniques to improve system precision.

Radio Science and Support Studies

Radio science and support studies provide the technical basis for regulatory and policy development to assure the orderly growth of existing and new satellite services. Unique analytical tools are developed and used to solve problems of inter- and intra-satellite/terrestrial system interference. Emphasis is placed on orbit and spectrum utilization studies which include the development of frequency and orbit sharing techniques and strategies, design standards, and the determination of the effect of propagation phenomena and man-made noise on performance, design, and efficient use of the geostationary satellite orbit and the radio spectrum.

During FY 1988, the radio science and support studies program will continue further development of a geostationary arc allotment concept as part of the U.S. preparations for the FY 1988 Space WARC. Also, propagation studies will continue to help minimize radio signals atmospheric interference problems in space communications.

During FY 1989, major emphasis of the radio science and support studies program will be studied to identify and quantify the adverse effects of propagation phenomena on satellite communications as well as remote sensing. Work will coninue to identify systems and technologies that make effective use of the frequency spectrum and geostationary orbit.

Communications Data Analysis

The objectives of communications data analysis are to support and to document a wide range of user experiments and demonstrations of the application of satellite communications. Past experiments on experimental satellites, such as the Applications Technology Satellite (ATS) series and the Communications Technology Satellite (CTS), have successfully provided users with the experience necessary to make informed decisions regarding the satellite communications functions. NASA's role to stimulate use of unique space facilities has led to wider applications of commercial satellites that better meet the needs of potential users.

The remaining ATS satellite, ATS–3, continues to support NSF, NOAA, the Department of Commerce, the Department of Interior, the Drug Enforcement Administration, several universities, state and local governments, and a number of domestic and international disaster relief organizations. Support is provided through satellite voice and data links for Scientific and communications experiments to North and South America, most of the Atlantic Ocean, and a large part of the eastern Pacific, including Hawaii and Antarctica.

Communications data analysis support of ATS–3 will continue, as will experiment definition and data analysis for laser communications analysis.

Communications data analysis, formerly the experiment coordination and operations support, assists other federal agencies and public sector organizations in the development of experimental satellite communications for emergency, disaster and public service applications. Operation of the ATS-3, launched in 1967, will continue.

Communications—Committee Comments

The Committee authorizes $92,200,000 for Communications in FY 1989. This is $76 million above the President's request and would accommodate the continued development of the ACTS.

The Committee strongly supports the ACTS program because it is critical to the future of the United States in the world communications market. Furthermore, the Committee continues to believe that the development of the ACTS technologies is an appropriate research and development function of NASA.

The Committee funds that the OMB justification for the exclusion of any funding request for ACTS in FY 1989 is without merit and in direct conflict with the President's Directive on National Space Policy. The Committee expects funding for the ACTS program to be included in the FY 1990 budget submission.

At a time when the United States suffers from an adverse balance of trade and the Europeans and Japanese are mounting substantial threats to our share of the world communications market, the Committee believes it is essential that the government and private sector cooperate to share the high costs and risks associated with the development of new technologies. The ACTS program is patterned on such a cooperative venture and represents a conscious effort on the part of the Congress to sustain the Nation's leadership in communications.

The Committee instructs NASA to proceed vigorously with the ACTS program in order to have the satellite ready for launch in 1992.

The Committee wants both NASA and the prime contractor for the ACTS program to realize that the Committee was most displeased with the revelations and events that led to the restructuring and capping of the ACTS program contract in January of this year. The Committee expects the program to live within this cap and would look unfavorably upon attempts to exceed this cap. The fact that the management and instrument development problems have delayed the launch of the ACTS for nearly two years, from 1990 to 1992, is already cause for concern. As a result of this delay, the previous advantage the United States enjoyed over its foreign competition in the development of this advanced communications technology has now been diminished.

E. INFORMATION SYSTEMS—$22,300,000

The Committee authorizes $22,300,000 for Information Systems in FY 1989. This is the same as the President's request. However, this account could be required to absorb part of the $10 million general reduction to the Space Applications account.

Summary of FY 1989 funding levels

Data Systems	$11,400,000

Information Systems	10,900,000
Total Information Systems	[1] $22,300,000

[1] Could be required to absorb part of the $10 million general reduction to the Space Applications account.

The objectives of the Information Systems program are to: apply advanced data systems technology to support the data management, scientific computing and information systems needs of NASA scientific research programs; conduct research programs and projects in the area of information systems and related technologies to enhance scientific productivity in the handling and analysis of data acquired from space flight experiments and observations; and implement information system standards, coordinate data systems requirements, and promote multi-mission sharing to lower information systems costs.

The information systems program provides the focus for integrated information systems planning across OSSA scientific disciplines. This includes definition of an end-to-end architecture or planning model to exploit commonality of requirements as appropriate, and to define interfaces for integrating mission- and discipline-specific portions with common core capabilities. The information systems program also provides leadership in assessing and evaluating advanced techniques, capabilities, and technologies especially as they support the information systems requirements associated with the highly complex sensors, complicated operational scenarios, extended-duration missions and multi-disciplinary requirements anticipated during the Space Station era.

The FY 1989 information systems program will continue emphasis on science information systems in support of Space Science and Applications programs, includes the ocean, climate, land processes, and planetary and astrophysics systems. Emphasis will be placed on the coordinated development of these systems to promote interdisciplinary studies. In addition, emphasis will continue on the applications of computer science technologies to support the work of the NASA science disciplines. Funding is included for continued operation of scientific computing resources such as the NASA Space and Earth Sciences Computing Center, the Massively Parallel Processor, and the National Space Science Data Center. The information systems program will continue to develop common software to support ongoing research in the space and Earth sciences and continue development of data management and data archiving to support flight projects, science, applications, and research disciplines.

Information Systems—Committee Comments

The Committee authorizes $22,300,000 for Information Systems in FY 1989. This is the same as the President's budget request.

The Committee strongly supports the development and demonstration of advanced information systems and believes they are critical to the success of the Nation's space program.

5. Commercial Programs $57,900,000

The Committee authorizes $57,900,000 for Commercial Programs in FY 1989. This includes $19,100,000 for Technology Utilization

and $38,800,000 for Commercial Use of Space. This is the same as the President's request.

Summary of FY 1989 funding levels

Technology Utilization	$19,100,000
Commercial Use of Space	38, 800,000
Total Commercial Programs	$57,900,000

Technology Utilization

The NASA Technology Utilization Program is designed to strengthen the national economy and industrial productivity through the transfer and applications of aerospace technology resulting from NASA's research and development programs. To accomplish this objective, NASA has established and operates a number of technology transfer mechanisms to provide timely access of useful technologies to the private and public sectors of the economy. Almost every part of U.S. industry is affected by the technology transfer process, especially in such areas as automation, electronics, materials, and productivity. In the public sector, medicine, rehabilitation, transportation and safety are areas in which aerospace technologies have been especially beneficial. The specific objectives of the program are:

—To accelerate and facilitate the application of new technology into the commercial sector, thus shortening the time between the generation of advanced aeronautics and space technologies and their effective use in the economy;

—To encourage multiple secondary uses of NASA technology in industry, education, and government, where a wide spectrum of technological problems and needs exist;

—To develop applications of NASA's aerospace technology, including its unique facilities, to priority nonaerospace needs of the Nation.

NASA has continued its broad and comprehensive efforts to promote and encourage the effective applications and use of new and innovative aerospace technologies throughout the public and private sectors of the U.S. economy. Of particular note is the upward growth of industrial and business subscribers to *NASA Tech Briefs* which now exceeds 160,000 readers. This 100 percent increase since January 1985 represents a growth rate averaging over 5,000 new subscribers per month—an effective measure of the importance and value which U.S. industry places on new and emerging technologies.

Moreover, the NASA-sponsored Industrial Applications Center (IAC) network has made significant strides in developing effective linkages with state-sponsored institutions engaged in industrial and economic growth. This broadening and strengthening of the nationwide technology transfer network is continuing to gather momentum with nearly 30 of the 50 States now being linked to transfer products and services available through the IAC efforts. NASA expects to continue this effort during the balance of FY 1988 and into FY 1989. An additional milestone was reached in late 1986 when the Federal Laboratory Consortium (FLC) for Technology Transfer (established under P.L. 99-502) and NASA elected to enter into an agreement in early 1987 which establishes formal linkages between the IAC network and the various Federal laboratories. Based on the successful completion of an experimental program between the IAC at the University of Southern California and the FLC Farwest Region, IAC industrial clients will now be able to gain controlled access to Federal laboratories nationwide that are engaged in research and development activities of parallel commercial interest. This effort is spurring the acceleration of technology transfer and application of Federally-sponsored technologies into the mainstream of the U.S. economy. NASA is also seeking to familiarize and involve the private sector to a greater extent. The hiatus in Shuttle flights caused by the Challenger accident has shifted the focus of NASA's commercial programs from in-space experimentation to ground-based opportunities and exploitation of available technology. The IACs are a natural focal point for increasing awareness of available technology and opportunities.

Several important events occurred during the past 18 months in which several NASA-sponsored technology applications projects came to fruition. Among these was the first human implant of the Programmable Implantable Medication System (PIMS) at the Johns Hopkins University (JHU) Hospital in November 1986. This successful human application of PIMS culminates several years of an intensive collaborative effort between NASA, the JHU Applied Physics Laboratory, and various private sector firms, and initiates a two-year clinical test period in which over 20 implantations will occur. All of these applications during the test period will be for patients with chronic diabetes.

Finally, NASA authorizes experimental technology transfer programs involving process and product at the Jet Propulsion Laboratory (JPL) as a means to enhance access to that laboratory's technology by small and large industrial firms. In May 1986, NASA entered into a cooperative agreement with the non-profit California based Research Institute for the Management of Technology (RIMTECH) to introduce JPL technology to industrial users in the Southern California area. For an entry fee, RIMTECH clients are offered NASA's technical assistance, information retrieval services, licensing rights and the possibility of cofunding of projects in the development stage. NASA, in turn, fulfills its charter and accrues the benefits of a broadened high-tech base industry, incentives for JPL employee creativity, potential royalties from patent licensing, and reverse technology transfers to NASA and the JPL from industry. At present, 15 industrial firms are participating in these programs, and another 25 firms are expected to join within the next 12 months.

In FY 1989, NASA plans continued strengthening of the Technology Counselor network at its field installations to provide for expanded identification of NASA technical capabilities and expertise. This capability and expertise is necessary for matching and cross-correlating NASA technology with industry needs specified by NASA Industrial Applications Centers.

In FY 1989, a broadening of application team responsibilities also is anticipated to assist NASA Industrial Applications Centers in bringing together industrial client problems with existing aerospace technologies leading to project definition and industry driven cooperative projects. This effort will result in increased tangible and meaningful applications of aerospace technology in the private sector, thus enhancing the productivity and competitive posture of U.S. industry.

Finally, in FY 1989, NASA will utilize its existing dissemination center network to contact and acquaint U.S. industrial firms with opportunities to actively intereact and participate with NASA in technology transfer and space commercialization. Such contacts are envisioned on a face-to-face basis, with appropriate follow-up including seminars, conferences and workshops to explore more detailed characteristics of the "opportunities" for interaction.

Commercial Use of Space

The goal of the Commercial Use of Space program is to establish a national focus in support of opportunities for the expansion of U.S. private sector investment and involvement in civil space activities. The specific objectives of the program are to:

—Establish close working relations with the private sector and academia to encourage investment in space technology and the use of the *in situ* attributes of space—vacuum, microgravity, temperature and radiation for commercial purposes.

—Facilitate private sector space activities through improved access to available NASA capabilities and the development of the new high technology space ventures and markets.

—Encourage an increase in private sector investment in the commercial use of space, independent of NASA funding.

—Develop and implement commercial space policy NASA-wide.

Sixteen Centers for the Commercial Development of Space (CCDS) have been established since the start of the program. The average cost of a CCDS is just under $1,000,000 per year. Several CCD's have developed strong linkages with the private sector and are developing flight hardware for applied research in space.

In order to maintain momentum in commerical use of space activities, NASA will develop methods to facilitate private sector agreements and commitments to develop commercial opportunities in space. Institutions with strong research capabilities in sciences and engineering, in collaboration with industry and/or industrial associations, will be encouraged to participate in NASA-sponsored workshops and endeavors to accelerate U.S. commercial leadership in the use of space. Resources support and technical assistance will be partially furnished by NASA with the remainder furnished by the Center for the Commercial Development of Space.

NASA's goal of expanding opportunities for U.S. private sector investment and involvement in civil space and space-related activities will be partially achieved by increasing the amount of space-related research conducted by the private sector, the number and type of NASA and private sector facilities available for space use, and the private sector awareness of the opportunity to use NASA's terrestrial and space-based facilities for potential commercial research.

Through coordination with various industrial sectors and NASA program offices, the commerical research and development enhancement efforts will provide generic, multi-use research experimentation equipment. This equipment, as well as ground-based hardware, software and analytical tools, will be developed in order to expand the technical research data base on the commercial uses of space required by the private sector to help make economic decisions to commit to research and, potentially, manufacture.

The NASA support for Joint Endeavor Agreements (JEAs) is directly proportional to the number of commercial research and development flight experiments scheduled, and it is intended to encourage private sector use of space facilities. The use of ground-based research facilities, aircraft and sounding rockets for commercial experimentation will be given emphasis in order to provide limited access to the microgravity environment for certain commercial experiments.

Commercial Programs—Committee Comments

The Committee authorizes $57,900,000 for Commercial Programs in FY 1989. This inlcudes $19,100,000 for Technology Utilization and $38,800,000 for Commercial Use of Space. This is the same as the president's budget request.

The Committee was pleased with the findings of the January NASA Report on how the NASA Technology Utilization Program places emphasis on projects and activities in applying technology to meet the needs of individuals with disabilities in the areas of employment, education, housing and recreation. The Committee believes this is and should continue to be an area of emphasis within NASA and that NASA should make every effort to disseminate information on technology transfer to these critical areas.

The Committee continues to support (CCDS) and the development of multi-user, multi-use government hardware. The Committee believes these two initiatives are a realistic approach to promoting commercial space activities. The combined involvement of government, industry and the university sectors in these activities is seen as a critical element of their potential success. However, based upon the Committee's review of the President's "Space Policy and Commercial Space Initiative to Begin the Next Century," the proposed request for proposal for a Commercially Developed Space Facility, and other related issues, the Committee realizes that there are still substantial differences of opinion as to the feasibility of "truly" commercial space activities and the type of Federal incentives and inducements that are required. While support for the CCDS program is broad-based, most other initiatives contained in the President's commercial space policy surface a variety of questions and issues.

The Committee is concerned that unrealistic expectations of space commercialization may fall short of the near-term realities and that over the long-run, this could affect adversely support for and the potential benefits of these activities.

The Committee also is concerned that non-operational space agencies, on occasions, have detracted from the administration's space commercialization process, and, consequently some space activities have suffered. The Committee is also concerned that certain fundamental budgetary and policy concerns have not been addressed adequately in all cases in the space policymaking process. The negotiations between the Committee, NASA and OMB concerning the Commercially Developed Space Facility clearly highlighted some of these deficiencies on the part of the executive and legislative branches.

The dilemma for the Committee is how to establish a commercial space policy with reasonable expectations and guidelines when it is not permitted access to the administration's space policymaking apparatus until after the fact.

Clearly, in the eyes of the Committee, NASA has a dominant role in the promotion of commercial space activities—and, on occasion, NASA has been uncertain of its appropriate role. However, the Committee is hopeful that this situation has been ameliorated and will continue to improve. Yet, because other federal agencies are involved with commercial space policy formulation, NASA is often unable to represent fully the Administration's position, and this has caused confusion at times. However, the Committee continues to believe that NASA is the key to the implementation of space commercialization.

The Committee recognizes the need for a consensus on space commercialization. It is unfair for U.S. companies and space entrepreneurs to be caught between the executive and legislative branches and to be faced with unclear and confusing guidelines and policies. To correct this deficiency, the Committee urges NASA and the administration to establish a Working Group with the Congress on space commercialization. Initially, this Working Group could consist of appropriate staff members who would seek to identify some near-term goals and guidelines that could give additional momentum to space commercialization. It would be the hope of the Committee that this Working Group could help support space commercialization and, where indicated, recommend changes to the administration's commercial space policy.

The Committee expects to work closely with the Office of Commercial Programs in formulating a reasonable commercial space policy, and the Committee has enlisted the assistance of the Congressional Budget Office (CBO) in this matter. (CBO has been asked to prepare a report on space commercialization.) It is still quite clear to the Committee that there are more questions than answers regarding commercial space initiatives and that much work needs to be done to ensure the success of space commercialization. However, the Committee is committed to asking the hard questions, finding the solutions, and proposing the best remedies and policies.

Finally, the Committee would like to indicate that it endorses NASA's proposal for use of external tanks in compliance with the President's Commercial Space Policy. The terms and conditions outlined in NASA's solicitation for expressions of interest in use of external tanks, as printed in the *Commerce Business Daily* on May 27, 1988, are agreeable to the Committee and represent a prudent strategy.

6. AERONAUTICAL RESEARCH AND TECHNOLOGY—$404,200,000

The Committee authorizes $404,200,000 for Aeronautical Research and Technology in FY 1989. This is $10 million less than the President's request and reflects a general reduction.

Summary of FY 1989 funding levels

Research and Technology Base	$314,200,000

Systems Technology Programs	100,000,000
Total Aeronautical Research and Technology	[1] $404,200,000

The goal of the NASA aeronautical research and technology program is to conduct research which contributes to a technology base that enables preeminence of U.S. civil and military aviation. This goal is supported by five comprehensive program objectives: (1) emphasize emerging technologies with potential for order of magnitude advances in capacity or performance which will enhance the U.S. defense and economic competitiveness; (2) maintain NASA's laboratory strength by repairing and modernizing critical aging national facilities, ensuring that necessary advanced scientific and engineering computational capabilities are available, and enhancing staff technical excellence by selecting highly qualified personnel and providing them with challenging career opportunities; (3) ensure the timely transfer of research results to the U.S. aeronautics community through reports, conferences, workshops, and active participation of industry in cooperative research programs; (4) ensure the strong involvement of universities in NASA's program to broaden the nation's base of technical expertise and innovation; and (5) provide technical expertise and facility support to DOD, other government agencies, and U.S. industry for major aeronautical programs. These objectives require a broad program of fundamental research that focuses on critical technologies and accelerates technology readiness for future vehicles. The program is based on a strong commitment to revitalize American competitiveness in the world aviation marketplace, enhance the safety and capacity of the national airspace system, and assure U.S. superiority for national security.

The NASA aeronautical research and technology program is intended to develop and validate emerging technologies for use by the aviation industry well in advance of specific applications through long-term independent research and technology development which is not driven by the development and operational pressures often encountered by DOD and industry. Fundamental research in the traditional aeronautical disciplines is pursued concurrently with systems research and technology validation.

With the U.S. superiority in aeronautics challenged as never before, the FY 1989 budget request reflects the need to accelerate technologies which are vital to long-term U.S. competitiveness, to continue a strong program in fundamental disciplines and in key areas of systems research, and to revitalize critical NASA wind tunnels. NASA's FY 1989 aeronautics program is focused on achieving the bold objectives established in the report, "National Aeronautical R&D Goals: Technology for America's Future," by the Office of Science and Technology Policy, and by its sequel report, "Agenda for Achievement," which enunciates an eight-point action plan for achieving the goals.

The FY research and technology program is committed to developing the technology basis for improving the nation's competitiveness and clear-cut product superiority in the international marketplace, enhancing the safety of aviation, and increasing the margin of the country's preeminence in aviation for national security.

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[1] Reflects general reduction of $10 million.

Technologies are being pursued that offer an order of magnitude increase in vehicle capabilities and a substantially positive impact on U.S. competitiveness. Research efforts have been expanded in composite materials, advanced propulsion, and aviation safety. The demands for NASA's unique wind tunnels are growing with the emergence of the national aero-space plane (NASP) program, research on high speed civil transports, and a new generation of military aircraft. In order to ensure wind tunnel availability to meet these demands, a major revitalization program is required over the next five years to modernize NASA's major wind tunnels for productive use for the next decade and into the 21st century. This program is included in the FY 1989 construction of facilities budget.

A. RESEARCH AND TECHNOLOGY BASE—$314,200,000

The Committee has authorized $314,200,000 for FY 1989 for Research and Technology Base. This is the same as the President's request. However, this account could be required to absorb part of the $10 million general reduction to Aeronautical Research and Technology.

Summary of FY 1989 funding levels

Fluid and Thermal Physics Research and Technology	$26,500,000
Applied Aerodynamics Research and Technology	64,300,000
Propulsion and Power Research and Technology	70,100,000
Materials and Structure Research and Technology	40,100,000
Information Sciences Research and Technology	23,000,000
Controls and Guidance Research and Technology	35,700,000
Human Factors Research and Technology	19,700,000
Flight Systems Research and Technology	28,800,000
Systems Analysis	6,000,000
Total Research and Technology Base	[1] 314,200,000

[1] Could be required to absorb part of $10 million reduction to Aeronautical Research and Technology.

Fluid and Thermal Physics Research and Technology

In fluid and thermal physics, increased research emphasis will be placed on analytical, computational, and experimental studies of turbulence through the focused efforts of a newly formed center for turbulence research. In fundamental fluid physics, investigations using the numerical simulation of the flow instabilities which produce transition from laminar to turbulent flow will be accelerated, leading to an improved understanding of both the mechanisms of transition and the control of transition. This knowledge can enable reductions in aircraft drag and simplification of aircraft thermal management systems. Hybrid laminar flow control for aircraft drag reduction will be validated experimentally through a flight test research program initiated in FY 1989.

Applied Aerodynamics Research and Technology

The objective of applied aerodynamics research and technology is to provide new, validated technology applicable to future U.S. military and civil aircraft from subsonic to hypersonic speeds. The approach is to conduct comprehensive ground and flight experiments involving realistic vehicle configurations and key configuration components. Such work is focused on technology areas expected to render major gains in advanced vehicle performance.

In applied aerodynamics, efforts will focus on high-angle-of-attack and separated flow aerodynamics in both ground and flight test. Control of separated flow will be studied to determine cellular formation, control, and wing stall departure and spin resistance. Boundary-layer transition will be investigated for all speed regimes. By utilizing advanced optical and electronic technologies, innovative wind tunnel instrumentation will be developed for infrared boundary-layer transition visualization, micro-encapsulated liquid crystal methods for advanced flow visualization, laser fluorescence for hypersonic flow sensing, and laser velocimetry for supersonic and hypersonic shock propagation measurements. Experimental hardware, which has been under development for the past two years, will be used in an experimental flight investigation program to validate hybrid rotocraft computational fluid dynamic codes for the prediction of rotor airloads and their resultant effects on aircraft vibration and acoustics.

Propulsion and Power Research and Technology

The objective of the propulsion and power research and technology program is to provide the understanding of the governing physical phenomena occurring at the disciplinary, component, and subsystem levels that will support and stimulate future improvements in propulsion system performance capability, efficiency, reliability, and durability. Research is being conducted in a wide variety of subsystems with applications ranging from the general aviation class through the hypersonic aerospace plane.

Propulsion research will continue to emphasize improvement of the fundamental understanding of stationary and rotating component flow fields with the development of unsteady, viscous, computational analysis methods and enhanced experimental verification through three-dimensional nonintrusive measurement capabilities. The focus will be on several specific propulsion technology developments: high-rate fuel injection and adiabatic components for rotary engines, offering a potential for improvement of 40 percent in fuel consumption and 30 percent in power density; axicentrifugal compressor staging arrangements and uncooled radial flow turbines, offering the potential for a 40 percent improvement in efficiency for small gas turbines; powered-lift components (inlets, ducts, augmenting fans, ejectors) and control integration, providing significant improvements for advanced short takeoff and vertical landing vehicles; and the critical component data base needed for hypersonic propulsion. Increased emphasis on advanced propulsion concepts will enhance the technology development of four innovative configurations, offering the potential for high payoff improvements in future propulsion systems; high throughflow turbomachinery, offering a 20 percent range increase for a Mach 3 cruise mission; air turboramjet cycle for extending variable cycle flexibility for the Mach 0 to 6 regime; variable geometry components, providing performance tailoring for multiple operating conditions with a 15 to 25 percent reduction in specific fuel consumption and 10 to 15 percent increase in thrust-to-weight ratio; and an off-axis, high-pressure core, offering the potential for a 20 to 30 percent increase in efficiency.

Materials and Structures Research and Technology

The objectives of the materials and structures research and technology program are to: (1) develop and characterize advanced metallic, ceramic, polymer, and composite materials; (2) develop novel structural concepts and design methods to exploit the use of advanced materials in aircraft; (3) advance analytical and experimental methods for determining the behavior of aircraft structures in flight and ground environments; and (4) generate a research data base to promote improvements in performance, safety, durability, weight reduction of up to 40 percent, and reductions in aircraft life cycle cost. Areas of emphasis include high-temperature engine and airframe materials and structural concepts, composite materials applications, life prediction, thermal and dynamic response including aeroelasticity, helicopter structural dynamics and airloads, and more accurate and efficient integrated design optimization methods for airframes and engines.

In FY 1989, the materials and structures program will continue to develop advanced materials and innovative structural concepts aimed at reducing aircraft weight and cost. These include high-temperature aluminum alloys for subsonic and moderate supersonic speed aircraft, regenerative cooling of hypersonic aircraft, and deformable wing structures for high-performance aircraft. In addition, increased emphasis will be placed on developing high-temperature composites technology for use at up to 600 degrees Fahrenheit. The composites program will focus on the development of advanced materials, advanced fabrication methods that are especially tailored to take advantage of composite material characteristics, advanced structural concepts, and design and qualification test methods. Advanced structural concepts and fabrication methods will include filament winding and protrusion techniques to reduce parts count for structures and subsystems, while new design and qualification methods will reduce structural design and testing costs. These areas will be supported by continued development of advanced computational methods of reduce structural design time and minimize costly testing. Also during FY 1989, greater emphasis will be placed on analysis of large-scale airframe structures using advanced multiprocessor computers.

Information Sciences Research and Technology

The objectives of the information sciences research and technology program are to provide the fundamental capabilities: (1) to exploit advanced computer architectures to meet NASA's unique computing requirements, (2) to increase the agency's ability to develop high-quality aerospace systems software, and (3) to provide the advanced theory, concepts and capability to effectively use and manage aerospace information.

Research in information sciences and will continue on concurrent processing for highly reliable and high-performance computer architectures which will be more immune to hardware and software failures. A family of parallel processing computers will be used to research novel concepts in parallel processors controlled by new software algorithms. Also, studies will continue to assess the reliability gain from formal specifications, software prototyping, computer-aided software engineering systems, software, reuse, and formal verification. Support will be provided to NASA's computer networking system in order to increase the effectiveness and productivity of NASA's distributed computing resources.

Controls and Guidance Research and Technology

The specific objectives of the controls and guidance program are: (1) exploitation of emerging controls, guidance, and artificial intelligence technologies for the development of advanced automation concepts; (2) development of highly reliable system architectures and validation methods leading to flight-crucial systems; (3) development of sensors for airborne wind shear detection and flight management avoidance techniques; (4) development of advanced control, guidance and display theories, concepts, and analysis methods; and (5) development of new methodologies for achieving multidisciplinary integration.

In controls and guidance, the advanced transport systems research vehicle (B–737) has returned to flight research status after overhaul and upgrade of its avionics systems, and emphasis will be placed on flight evaluation of takeoff and landing performance monitoring, high-speed rollout and turnoff capacity improvements, and navigation systems for reduced airport congestion and delays. Increased emphasis will be placed on development of automation concepts leading to enhanced safety and productivity in the national airspace system. Adopting state-of-the-art space automation techniques and methods, evaluations will be conducted jointly with the Federal Aviation Administration (FAA) at the Stapleton Airport in Denver, of an air traffic controller advisor and expert schedule advisor. These evaluations offer the promise of allowing reductions in controller workload and more efficient handling of air traffic. In FY 1989, research will continue on the detection, avoidance, and recovery from wind-shear encounters.

Human Factors Research and Technology

The objective of the aeronautical human factors research and technology program is to provide the capability to design effective crew-cockpit systems using advanced cockpit automation technologies which will properly integrate the diverse systems, operators, and procedures within the mission requirements and environment. This is necessary for safety, productivity, efficiency, and increased effectiveness in advanced commercial and military aircraft, rotorcraft, and the NASP program. Human capabilities and limitations of crew personnel and their interactions with systems, components, procedures, and flight requirements are determined and refined in order to delineate guidelines. These guidelines provide the road map to understand how to integrate the crew with automation technologies in the cockpit. There are four areas of emphasis: (1) flight management, (2) human engineering methods, (3) rotorcraft, and (4) subsonic transports.

Human factors research will emphasize the development of methods for designing pilot decision aids and information transfer improvements in order to increase safety and reduce peak workload. To address the fact that over the last 30 years approximately 70 percent of the world-wide jet fleet accidents were caused by human error, the human factors research will be accelerated in areas directly related to aviation safety and automation. This research will emphasize the development and validation of methodologies for intelligent, error tolerant systems; improved human/automation interfaces for increased situational awareness; and aircraft/active control technology integration. The goal of this activity is to reduce substantially the risk of human error.

Flight Systems Research and Technology

The objective of the flight systems research and technology program is to provide the necessary research and technology development for an improved an validated base of advanced technology for application by industry to future generations of the entire spectrum of aircraft. In many cases, joint funding is provided by NASA, (DOD, and the FAA. The program is organized into the following categories: (1) aviation safety; (2) flight instrumentation and test techniques; (3) fighter/attack aircraft; and (4) flight support. The activities within this program encompass advanced engineering techniques and the establishment of the feasibility of concepts to ensure rapid application of promising new technology essential to meeting one or more of the following goals: (1) reducing aircraft accidents resulting from weather effects (heavy rain and icing); (2) improving flight efficiency, enhancing data accuracy, and enabling the acquisition of needed information; and (3) establishing a technology base for the design of future fighter aircraft with unprecedented maneuverability at high-angle-of-attack (up to 90 degrees) flight conditions and vertical landing capability.

In FY 1989, flight systems research will be directed toward the technology needs of aviation safety, flight test methodologies, and supporting research for high-performance aircraft. Research is being conducted to improve the understanding of the effects of weather and icing conditions on the safe operation of aircraft and rotorcraft and to develop the technologies which will improve the safety of future vehicles. Research will be conducted using the F-18 high-angle-of-attack research aircraft to validate emerging experimental and computational methods for the prediction of high-angle-of-attack aerodynamics, flight dynamics, and handling qualities.

Systems Analysis

Systems analysis research studies will focus on defining the research and technology requirements for advanced high-speed transport aircraft. Emphasis will be placed on assessing the impact of advanced technologies for reducing engine emissions, sonic boom, and airport noise. The goal of this research is to ensure that future high-speed civil transports will be environmentally compatible with respect to concerns about atmospheric ozone depletion and noise. Advanced supermaneuverability fighter configurations will be analyzed to determine the benefits of advanced technologies in aerodynamics, propulsion, materials, structures, and controls.

B. SYSTEMS TECHNOLOGY PROGRAMS—$100,000,000

The Committee authorizes $100 million for Systems Technology Programs in FY 1989. This is the same as the President's request. However, this account could be required to absorb part of the $10 million general reduction to Aeronautical Research and Technology.

Summary of FY 1989 funding levels

Materials and Structures Systems Technology	$29,200,000
Rotorcraft Systems Technology	4,800,000
High-performance Aircraft Systems Technology	11,000,000
Advanced Propulsion Systems Technology	14,000,000
Numerical Aerodynamic Simulation	41,000,000
Total Systems Technology Programs	[1] $100,000,000

[1] Could be required to absorb part of the $10 million general reduction.

Materials and Structures Systems Technology

The objective of the materials and structures systems technology program is to develop advanced materials and structural concepts for future advanced aircraft propulsion systems and primary structures.

In FY 1988, the turbine engine hot section technology element and the ceramics for turbine engines element were combined and augmented to form the advanced high-temperature engine materials technology program. The programs were combined to focus their efforts on developing fundamental technology for revolutionary advances in high-temperature materials for advanced propulsion systems.

The objective of the advanced composite materials systems technology program is to develop advanced materials and innovative structural concepts to fully exploit the benefits of advanced composite materials for cost-effective primary structures for future aircraft applications. The program objectives will be accomplished through materials development, design and fabrication of innovative structural concepts, structural analysis and improved life prediction methods, and demonstration of improved structural performance through subscale and full-scale tests of critical components representative of advanced composite airframe structures.

For FY 1989, advanced high-temperature engine materials research will emphasize fiber development, composite mechanics, and interfaces. Strong, stiff, lightweight reinforcement fibers, which are capable of maintaining chemical stability and mechanical properties at elevated temperatures, are a central issue to this entire program.

During 1989, advanced composite materials and structures research in the Research and Technology Base will focus on developing fundamental technology for application of composites to primary airframe structures. This research will be directed toward exploiting new organic-composite materials for use at up to 600 degree Fahrenheit and advanced processing and fabrication concepts for low-cost composite structures.

Rotorcraft Systems Technology

The rotocraft systems technology program consists of interrelated research on three fronts: (1) completion of noise prediction and reduction in cooperation with industry, (2) increased focus on technology for high-speed rotocraft, and (3) completion of the flight research on the X-wing concept under a joint program with the Defense Advanced Research Projects Agency.

In FY 1989, the program will increase the effort on high-speed rotocraft. In noise technology, with the completion of the NASA/American Helicopter Society noise program and the release of their ROTONET code, the emphasis will shift to in-house acoustics research for military application and specific issues for high-speed rotocraft designs. In addition, prediction of tilt rotor noise will be validated in all flight modes in order to understand the source phenomena and potential areas for reduction.

Cooperative efforts will also take place with the FAA for civil certification issues and with the Navy for V–22 tilt rotor technology assistance. The immense payoff of this technology for the nation through civil application is recognized in the government and by the industry and regional transportation authorities.

In FY 1989, the Rotor Systems Research Aircraft X-wing research program will be concluded. The completion of the flight tests of a full-scale X-wing rotor will provide the data base for determining the next step in the development of this technology which offers significant potential for high-speed rotocraft applications.

High-Performance Aircraft Systems Technology

The objective of the high-performance aircraft systems technology program is to generate validated engineering methods and design data applicable to the development of advanced high-performance, high-speed aircraft applications. The program objectives are accomplished by analysis, ground-based simulations, wind tunnel experimental research, and flight research tests of advanced aircraft concepts and systems.

The flight research activity in FY 1989 will involve several high-performance aircraft tests designed to investigate advanced concepts. Several projects will continue their flight phases during this period including the X–29 aircraft (No. 1 and 2) and the F–18 high-angle-of-attack research aircraft.

Advanced Propulsion Systems Technology

The objective of the advanced propulsion systems technology program is to explore and exploit advanced technology concepts for future aircraft propulsion systems in high-payoff areas through the focusing of fundamental research and technology efforts and integration of advanced propulsion components.

Activities in the advanced turboprop systems program are devoted to establishing concept feasibility and providing the broad research and technology analytical and experimental data base necessary for achieving the concept's full potential.

In FY 1989, advanced turboprop systems research will continue to emphasize source noise, cabin environment, turboprop and airframe installation aerodynamics, and the development of advanced aerodynamic and structural analysis techniques for both single- and counter-rotation propellers.

In addition, in FY 1989, the general aviation/commuter engine technology effort will continue to demonstrate component improvements through the practical application of validated analysis codes that will enable high-performance small engine systems.

Numerical Aerodynamic Simulation

The numerical aerodynamic simulation (NAS) program objective is to significantly augment the nation's capabilities in computational fluid dynamics and other areas of computational physics by developing a preeminent capability for numerical simulation of aerodynamic flows. Ongoing research and technology base efforts in computational aerodynamics are benefiting significantly from the advanced computational capabilities to be provided by the NAS program. This program provides the computational capabilities required to obtain solutions to problems which are currently intractable.

FY 1989 will be an important year in the development of the NAS system. The second high-speed processor will be integrated into the NAS system. This event had slipped due to unavailability of a supercomputer meeting the HSP-2 requirements. With HSP-2 integrated into the system, secure processing will be available while users have access to the other high-speed processor.

With the second processor, the number of users and projects supported by NAS will increase accordingly. Support processing will be upgraded to satisfy the additional requirements of the system. Mass storage continues to be a primary concern for computer systems. The NAS program will double the mass storage capacity in late FY 1989, and efforts with industry on developing more capable systems are being pursued.

Aeronautical Research and Technology—Committee Comments

The Committee authorizes $404,200,000 for Aeronautical Research and Technology in FY 1989. This is $10 million less than the President's budget request. However, the Committee would like to indicate that in the absence of extreme budget constraints, no general reduction would be imposed.

The Committee was most pleased with the FY 1989 budget request. For the first time in many years, the first "A" of NASA, the "A" for Aeronautics, received a well-balanced budgetary and programmatic commitment—a commitment in line with a program that represents more than a $15 billion surplus to the U.S. balance of trade.

The Committee also was pleased with the details of the "Civil Aeronautics Technology Development and Validation Plan" and the "Major NASA Wind Tunnel Revitalization Program" reports. These documents have been well-received by the Committee and have significantly influenced the formulation of the FY 1989 NASA Authorization Bill (discussion of the "Wind Tunnel Revitalization Program" is under "Construction of Facilities—Committee Comments").

The Civil Aeronautics Technology Development and Validation Plan, prepared at the request of this Committee of NASA in conjunction with private industry, describes the technological efforts required in the next decade to assure continued U.S. leadership in future civil aircraft markets. The plan is consistent with the recommendations of the 1987 report entitled "National Aeronautical R&D Goals, Agenda for Achievement," issued by the Aeronautical Policy Review Committee, and describes a technology program that could be implemented in each of three areas to enhance U.S. competitiveness in future civil aircraft markets—subsonic transport, high-speed civil transport, and civil tiltrotor and commuter aircraft. This plan clearly substantiates the need for both technology development and validation, including flight testing, if the United States is to continue to be a leader in aeronautics.

In the first three decades of the next century, the commercial transport aircraft market is projected to total about $1.5 trillion in 1988 dollars, with an annual world market of $50 billion per year—2½ times the projected annual market for the rest of this century. Clearly, this is a market in which the United States must maintain its competitiveness in the future. Continuing advances in efficiency and performance of subsonic transport aircraft are key to maintaining our positive trade balance in this important market sector and to preventing a further decline in the U.S. share of the world aviation markets.

Implementing the plan for development and validation of technology for subsonic transpaort aircraft should provide substantial benefits to both derivative and new transport aircraft, provided the aircraft industry is prepared to incorporate the technology into its products. Consequently, emphasizing areas consistent with the industry's priorities for various technologies is a key means to early applications—the joint development of the plan by NASA, and the aircraft industry reflects that approach. A further assurance of early application of the technology is the willingness of industry to invest in the technology development and validation costs with the government. A successful recent example of joint NASA and industry investment in systems technology development is the Advanced Turboprop Program (ATP), wherein the industry has shared a significant portion of the program costs, and the the technology results are being applied in new propulsion systems now in development by the industry. The Committee recommends that NASA and the industry identify those technology development and validation efforts for subsonic transport aircraft which the industry is willing to share costs, to an extent similar to the ATP program. To that end, the Committee recommends that NASA request funding for those efforts starting in FY 1990.

A large component of the projected worldwide transport aircraft market and the only major new opportunity in this market sector is in high speed transports for the long-range trans-Pacific routes. By 2025, this market segment alone is projected to be larger than today's subsonic transport market—with potential sales of 1,500 high speed commercial aircraft. The need to carry 300,000 passengers daily to the Pacific rim nations will profoundly impact the aircraft and airline industries in the next century and will drive the requirement for long haul, high speed transport aircraft.

Although the primary requirement for a high speed commercial transport aircraft will certainly be economic soundness, environmental acceptability will also be a major factor in the success of such an aircraft. As a consequence, the initial emphasis in the technology development and validation program should be focused on the technologies that could lead to an environmentally acceptable aircraft through reductions in aircraft engine noise and emissions and sonic boom overpressure level. Therefore, the Committee requests that NASA initiate those elements of the proposed program in FY 1989 that could produce early information on the environmental issues and increase that emphasis on those technnologies in its FY 1990 program.

Tiltrotor aircraft technology has been under development by the DOD and NASA for several years and will be demonstrated and further developed in the V-22 Osprey program. Results obtained from the V-22 program and further studies of intercity air transportation needs should provide information at some future time to determine whether additional efforts to develop a civil version of the tiltrotor design are justified.

Commuter aircraft technology has also been a focus of the NASA aeronautics program for many years, and there are many advances in technology available that have not been incorporated in this class of aircraft. The competitiveness of this segment of the U.S. aircraft industry is overwhelmingly affected by factors unrelated to technology. Therefore, the Committee recommends that the current level of effort in this area is appropriate.

Finally, the Committee would like to indicate that it is so intrigued with recent reports—government and non-government reports—concerning the potential markets for a new high speed commercial transport that it held an all-day workshop at the Library of Congress on May 24, 1988, to explore this issue. The Committee hopes that the results of this workshop, combined with the results of these additional reports, will result in a fiscal year 1990 initiative for a more efficient, environmentally sound, high speed commercial transport.

7. TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY—$69,400,000

The Committee authorizes $69,400,000 for Transatmospheric Research and Techology in FY 1989.

Summary of FY 1989 funding levels

Transatmospheric Research and Technology	$69,400,000

The National Aero-Space Plane (NASP) program is a joint effort between NASA and DOD to accelerate the development of critical enabling technologies for a revolutionary class of hypersonic-transatmospheric vehicles. Such vehicles could be capable of taking off from the landing on conventional runways, using airbreathing propulsion up to, or near, orbital speed, and providing rapid and lower cost access to space. The program will accelerate the development and validation of key technolgies through application of analytical prediction methods coupled with testing in ground-based facilities. The critical technolgies being pursued in the current phase of the program include efficient airbreathing propulsion systems, with emphasis on scramjet performance that provides the necessary thrust from takeoff to near orbital speeds; reusable thermal structures that can withstand repeated combinations of extreme peak heating and signficiant long-duration heat loads; and complete integreation of the propulsion system with the airframe for a minimum weight system with good performance throughout a broad range of accelerating cruising, and maneuvering flight conditions. A necessary precursor to the development and flight validation of an experimental vehicle (X-30), these technolgies will form the critical data base required for design and integration of complex propulsion and structural systems into a vehicle configuration capable of transatmospheric flight.

The FY 1989 NASP activities will emphasize extensive detailed design, component fabrication, and tests by the engine and airframe contractors, as well as continued refinement of the supporting technology maturation effort in preparation for the decision on whether to proceed with development of the X-30 research vehicle.

The engine contractors will continue to refine their concepts to achieve the performance required to accomplish the X-30 mission goals. Emphasis will be on integration with the vehicle configurations being developed by the airframe contractors, since the desired performance depends critically on the integrated propulsion-airframe system.

The technology maturation effort will continue to focus on critical disciplines as an underpinning of the engine and airfame efforts. The technology maturation activities concentrate on four key objectives: (a) an airbreathing propulsion system with high specific impulse; (b) vehicle structural weight improvement with reusability and durability over a wide temperature range; (c) integrated systems and subsystems in aeropropulsion, thermal management controls, etc; and (d) sound design and analysis tools based on advanced computational methods fully verified by test.

Finally, the major effort to scale up and characterize advanced lightweight, high-temperature materials in a cooperative effort with contractors begun in FY 1988 will be significantly expanded in FY 1989.

Transatmospheric Research and Technology—Committee Comments

The Committee authorizes $69,400,000 for Transatmospheric Research and Technology in FY 1989. This is $15 million less than the President's budget request.

The NASP program continues to represent an important opportunity for revolutionary advances in U.S. aeronautical and space capabilities. The most significant technological barriers to the successful completion of the NASP progam—air-breathing propulsion, structures and materials, and aerodynamic computational methods—will require many years of sustained effort and support if they are to lead to the development of a prototype and eventually an operational vehicle. While the Committee is fully aware of the fact that national security missions are the most likely early applications of this joint NASA/SOD program, in the long term the NASP offers the promise of enhancing our competitive position in several major areas of aeronautical research and development.

With the technology base that emerges from this program, the United States should be able to meet the competition that we face in this area from the Soviet Union, Japan, ESA and others.

Unfortunately, due to budget constraints and competing priorities, the Committee has approved only half of the proposed FY 1989 increase.

8. Space Research and Technology—$350,900,000

The Committee authorizes $350,900,000 for Space Research and Technology in FY 1989. This is $40 million less than the President's request.

Summary of FY 1989 funding levels

Research and Technology Base	$134,100,000
Civil Space Technology Initiative (CSTI) Program	156,800,000
Pathfinder	60,000,000
Total Space Research and Technology	[1] $350,900,000

[1] This includes a general reduction of $8 million for equipment and an augementation of $8 million for the Space Grant College and Fellowship Program.

The overall goal of the space research and technology progam is to provide advanced technologies that ensure continued U.S. leadership in space to meet national needs. Achieving this goal requires a commitment to provide a broad base of advanced technology for vehicle and subsystem concepts, components, devices, and software; to develop technical strengths in the engineering disciplines within the agency, industry, and academia; and to perform critical technology demonstrations that facilitate the transfer of new technology to future space missions with a high level of confidence.

The research and technology base program provides the well spring of innovative and fundamental research for future NASA and other civil space missions. Within this program, high-leverage technological advances and concepts are, if successful, brought to the level of demonstrating proof of principle. This program is in effect a seedbed for generating the more highly mission-focused program that consists of major technology thrusts to enhance Earth-to-orbit transportation, improve operational capabilities at low Earth orbit for enhancing the effectiveness of Shuttle/Space Station, and provide increased capabilities to conduct Earth-orbital science programs. The Pathfinder program provides those emerging and innovative technologies required to enable a broad set of future space exploration missions. Depending on future decisions, such missions could include a return to the Moon to build an outpost, and both autonomous and piloted missions to Mars and other destinations in the solar system. Proof-of-concept testing for mission-critical engineering designs will be an important product of the CSTI and Pathfinder programs and will directly support the continuing evolution and maturation of mission plans. In support of the objective of encouraging the development of engineering and research capabilities in the academic sector, the univeristy activities have been combined into a separate focused budget line item which includes the space engineering research center program, the university system design program, and univeristy innovative research.

In FY 1989, the space research and technology program will be significantly augmented to provide a greater emphasis on focused technology (CSTI and Pathfinder) and university space research programs. The research and technology base program will shift emphasis to explore newly emerging areas that offer longer range, high-leverage program benefits. The university space research program includes augmentation and expansion of the university engineering research centers and the university advanced design effort. Development of the concepts and plans for an expended in-space research and demonstration program will be pursued. The following described in greater depth the planned FY 1989 activities.

A. RESEARCH AND TECHNOLOGY BASE—$134,100,000

The Committee authorizes $134,100,000 for the Research and Technology Base in FY 1989. However, this account could be adjusted to reflect the $8 million general reduction for equipment and the $8 million increase for the Space Grant College and Fellowship Program.

Summary of FY 1989 funding levels

Aerothermodynamics Research and Technology	$11,500,000
Space Energy Conversion Research and Technology	13,800,000
Propulsion Research and Technology	19,700,000
Materials and Structures Research and Technology	17,500,000
Space Data and Communications Research and Technology	9,300,000
Information Sciences Research and Technology	9,000,000
Controls and Guidance Research and Technology	6,700,000
Human Factors research and Technology	5,300,000
Space Flight Research and Technology	18,100,000
Systems Analysis	6,900,000
University Space Research	16,300,000
Total Research and Technology Base	[1] $134,100,000

[1] Could be further adjusted to reflect the $8 million general augmentation.

Aerothermodynamics Research and Technology

The aerothermodynamics program provides the basis for fundamental understanding and prediction of the combined effects of heat transfer and aerodynamics on vehicles during ascent and entry. This activity is enabling to the successful development and design of advanced aerospace vehicles. Current program emphasis is on development and validation of computational fluid dynamics codes that incorporate real-gas and nonequilibrium effects to more accurately predict performance of aeroassisted orbital transfer vehicles.

Space Energy Conversion Research and Technology

The space energy conversion program provides the fundamental understanding and technology basis for the development of future space power systems ranging from relatively low power levels required for spacecraft to high-capacity, nonnuclear power for large space systems. Photovoltaic power technology will focus on improving the efficiency and reducing the degradation rate of photovoltaic cells through improved designs and materials. Technologies for lightweight deployment systems, reduced weight substrates, and ultrathin cover glass are being developed. Higher energy chemistry and improved battery designs are being developed to provide improvements in the energy density and life of storage systems. The goal is to improve the total system (photovoltaic and storage) performance to permit a 50 percent increase in payload weight. Research continues on fuel cells for application at higher power levels (greater than 25 kilowatts) where they offer significant potential weight advantages. New conversion catalyst materials and designs are being developed to achieve reduced system weight and to increase life. Technologies for high-efficiency thermal-to-electric conversion, high-temperature thermal storage, and lightweight high-concentration-ratio solar collectors are being developed for solar dynamic systems. The goal of these technologies is to provide a 25 percent reduction in collector area and a substantial reduction in weight over current high-capacity systems.

Propulsion Research and Technology

The propulsion technology program focuses on key lifetime and performance issues associated with space propulsion systems. Variable-flow turbomachinery, enhanced heat transfer combustors, and high-expansion-ratio nozzle technology for space-baseable orbit transfer vehicles will be investigated. The ultimate benefit will be to reduce substantially the cost of space operations by reducing the amount of mass required to be transported to Earth orbit. In addition, the potential of very high-energy-density propellant combinations, such as liquid oxygen with metalized fuels, will be assessed for Earth-to-orbit propulsion systems. For ascent vehicle operations, candidate propulsion systems that can operate efficiently with propellants produced *in situ* on Mars or on the Moon will be indentified and their performance and operational capabilities explored to greatly reduce Earth launch requirements. Research on auxiliary propulsion will develop concepts for control of an evolutionary space station and space vehicles which operate with mixtures of gaseous oxygen and hydrogen derived from electrolytic systems. Electric propulsion technology will address fundamental issues governing thruster life, performance, and weight through improved inert gas ionization processes and cathode materials and designs.

Materials and Structures Research and Technology

The materials and structures program will focus on extended space durability, structures for lighweight vehicles, and concepts to enable the development of large space structures. The dimensional stability and durability of metal-matrix, carbon-carbon and graphite-epoxy composites will be evaluated for long-term service life in both low-Earth-orbit and geosynchronous-Earth-orbit environments. The approach will include both the development or computational chemistry methods to describe atomic oxygen interactions and accelerated testing methods. Structural concepts will be developed incorporating mechanisms to adjust stiffness, damping, and shape in order to enable construction of large high-precision space structures. Hot structures for integral cryogenic tankage will be pursued, and toughened ceramic thermal protection systems will be developed.

Space Data and Communications Research and Technology

Space data and communications research will be directed toward increasing traveling wave tube efficiencies, developing and packaging monolithic microwave integrated circuit components, refining 20/30 gigahertz antenna technology, and advancing electro-optic research aimed at laser communications.

Information Sciences Research and Technology

Areas addressed by the information sciences program include computer sciences, sensors, and photonics. In the computer science area, emphasis will continue to be placed on concurrent processing for improved physical simulations and visualization of scientific data. Sensor research will concentrate on the use of artifical intelligence techniques in autonomous onboard data analysis. Investigation of new materials, devices, and analytical models leading to the development of improved sensor systems will continue. In the area of photonics, research will focus on improved photonic materials and devices for use in real-time computer vision systems and very low-cost, wide-bandwidth signal analysis.

Controls and Guidance Research and Technology

Controls and guidance research will support the implementation of future advanced Earth-to-orbit transportation systems, aeromaneuvering vehicles, and interplanetary space travel. Particular emphasis is being placed on real-time, fault-tolerant distributed control architectures and system autonomy in the real-time environment of a maneuvering vehicle. The development of analytical tools and techniques for the precision pointing and control of large flexible spacecraft and the control of extremely large flexible transportation vehicles is a principal research focus.

Human Factors Research and Technology

Space human factors research includes development of advanced concepts and hardware for extravehicular activity, such as hard space suits and development of highly intergrated displays and controls to support telepresence and astronaut and crew performance.

Space Flight Research and Technology

Space flight research includes the continued development of orbiter experiments to use the shuttle as a research testbed vehicle. The in-space technology experiments program was expanded to define and develop seven flight experiments selected from 58 NASA in-house generated proposals. The program was also expanded further by the selection of 41 externally sponsored flight technology experiments from 231 university and industry proposals.

System Analysis

The objectives of the systems analysis program are to identify technology requirements for prescribed mission concepts and opportunities for enabling new and improved concepts; to integrate these into a comprehensive technology set of planning options; and to generate candidate plans to develop these technologies in a timely manner. Close coordination with the Offices of Space Flight, Space

Science and Applications, Space Operations, Space Station, and Exploration and other users is maintained to ensure proper understanding of missions and to gain assistance in prioritization of enabling and high-leverage technologies. This analysis program is directed at the systems-focused areas of space transporation, spacecraft, and large space systems and at emerging, new mission concepts and mission-enabling technologies.

University Space Research

The objective of the university space research program is to enhance and broaden the capabilities of the nation's engineers community to participate more effectively in the U.S. civil space program. It is an integral part of the strategy to rebuild the space research and technology base. The program responds to remedy the decline in the availability of qualified space engineers by making a long-term commitment to universities aspiring to play a strong engineering role in the civil space program. The program elements include the university space engineering research program, which supports interdisciplinary research centers; the university innovative research program, which provides grants to individuals with outstanding credentials; and the university advanced space design program, which funds advanced systems study courses at the senior and graduate levels.

B. CIVILIAN SPACE TECHNOLOGY INITIATIVE (CSTI) PROGRAM—$156,800,000

The Committee authorizes $156,800,000 for the Civilian Space Technology Initiative Program in FY 1989. This is the same as the President's request. However, this account could be adjusted to reflect the $8 million reduction for equipment and the $8 million increase for the Space Grant College and Fellowship Program.

Summary of FY 1989 funding levels

Automation and Robotics	$25,900,000
Propulsion	46,700,000
Vehicle	28,000,000
Information Technology	17,100,000
Large Structures and Control	25,100,000
High-capacity Power	14,000,000
Total Civilian Space Technology Initiative Program	[1] $156,800,000

[1] Could be further adjusted to reflect the $8 million general reduction or the $8 million augmentation.

The CSTI is developing the technologies to enable reliable and lower cost access to space and to support enhanced space operations and science missions. Support for future space transportations systems includes: autonomous systems research and prelaunch and postlaunch operations; reusable, high-performance engines for next-generation launch vehicles; and a flight demonstration of aerobraking for orbit transfer vehicles. Future Earth-orbiting operations and science missions will be enhanced through an expanded effort in automation and robotics; technology to significantly increase data processing and storage capabilities; ground and in-space experiments to expand the design data base for very large, flexible structures; and technology for high-capacity nuclear power conversion systems. New sensor technologies and capabilities to deploy large, extremely precise surfaces will further enhance Earth and deep space observation.

The objective of the CSTI program, begun in FY 1988, is focused on research in technologies to enable reliable and lower cost access to space and to support space operations and science missions. The CSTI program is a positive first step to restore the agency's technical strength and provide options for high-priority civil space goals of the future. The research is targeted at opportunities with clearly defined end objectives to validate technology advances. Three broad categories—transportation, operations, and science technology—are supported.

Automation and Robotics

The objective of the automation and robotics program is to exploit the potential of artificial intelligence and telerobotics to increase the capability, flexibility, and safety of space and ground operations while decreasing associated costs. The goal of the robotics element is to evolve the capability for remote space operations from the current level of teleoperations (direct human control) of a single crane-like arm, through the telerobotic operation (human supervisory control) of dexterous multiarmed manipulators, to the robotic operation (human task-level control) of multiple intelligent manipulators. The goal of the autonomous systems element is the use of artificial intelligence technology to effect the reduction of manpower involved in ground control; automation of control of subsystems aboard the Space Station, spacecraft, and space transportation vehicles; and elimination of astronaut time spent performing housekeeping functions.

In FY 1989, the telerobot demonstration facility at the Ames Research Center will perform its first test in which all of its subsystems (artificial intelligence, run-time control, sensing and perception, operator control, and manipulation and control mechanization) are implemented. The task will be to remove and replace a module in the spacecraft mockup. This will be the first implementation of the concept of traded control in which the automatic control system and the human operator can pass control smoothly to each other during the task.

Research and development in each of the five robotics core technology areas also will continue. This includes task planning, operator interface, sensing and perception, control execution, and systems integration and architecture.

In addition, in FY 1989 the expert system for monitoring of shuttle communications will be tested during the next Shuttle flight, where it will operate in parallel with the human controllers who will have actual control. The expert system for control of the environmental control system during launch processing actually will be used during the next Shuttle launch. This will be the world's first operational use of artificial intelligence in a space mission.

Propulsion

The objective of the CSTI propulsion program is to provide a validated design and analysis capability that can be applied to the design and development of advanced propulsion systems for future low-cost reusable Earth-to-orbit (ETO) vehicles and recoverable boosters.

In FY 1989, the CSTI ETO propulsion program will continue to conduct LOX-hydrocarbon specific technology-tasks to verify high-pressure ignition, combustion performance and stability, heat transfer and cooling, and will begin the design and fabrication of appropriate large-scale technology turbopumps. Models and design concepts developed in the subscale research and technology base program will be used for the design of the large-scale hardware.

The Space Shuttle main engine testbed effort will include the final assembly of the testbed engine and the initial hot-fire operations utilizing the newly activated S1C test stand at the Marshall Space Flight Center. Research quality diagnostic instrumentation, including selected advanced technology sensors, will be installed and calibrated. Advanced technology components (turbine blades, diagnostic sensors) will be prepared for installation for the second hot-fire test sequence.

For the hybrid boosters system, FY 1989 efforts include evaluating candidate fuels, establishing burning characteristics, evaluating propellant configurations, selecting an oxidizer pump concept, evaluating spray concepts, and establishing the mechanisms for a safe abort option. For pressure-fed liquid booster systems, tasks include propellant selection, combustion stability characterization, pressurization systems, design, nozzle size and number optimization, and structural design and material evaluation. Both systems will enter the mid-size hardware fabrication and test phase in FY 1989.

The aeroassist flight experiment (AFE) will investigate the critical vehicle design and environmental technologies applicable to the design of the aeroassist orbital transfer vehicle. Aerodynamic braking maneuvers, which occur in the upper regions of the Earth's atmosphere at or near geosynchronous return velocities, produce aerothermodynamic environments that cannot be simulated in ground facilities or modeled using existing analytical techniques. It is necessary, therefore, to obtain critical aerodynamic and aerothermodynamic data from flight experiments.

The technology data base developed by the AFE will enable the use of aerosassist in conjunction with an orbital transfer vehicle to achieve minumum fuel expenditure in a return to low Earth orbit from a high energy orbit, such as geosynchronous.

In FY 1989, the preliminary design of the AFE spacecraft and associated ground and airborne support hardware will be completed, and final design initiated. Component structural testing on the aerobrake will begin. Software simulations will be conducted to evaluate guidance and navigation control schemes. Wind tunnel and arcjet testing will be continued to support the design data base for the AFE. Additionally, mission requirements will be defined, and a preliminary mission operation timeline prepared.

Information Technology

The objective of the information technology program is to discover, invent, and develop new materials, devices, components, and systems that will enable active and passive detection and imaging of electromagnetic radiation and subsequent data storage systems for space missions in the next century. Of special importance are tunable laser sources and millimeter wave sensors for both active and passive remote sensing of the Earth's atomsphere and surface.

In FY 1989, research efforts will proceed in three technically deficient areas: direct detectors and heterodyne frequency sources (local oscillators), frequency mixers, and quasi-optical components for the submillimeter portion of the electromagnetic spectrum.

In addition, in the active remote sensing area, the research effort will be focused on the necessary technology to implement solid-state laser systems for future missions.

Large Structures and Control

The objective of the large structures and control element of CSTI is to develop integrated structures and control technology to enable the development of large flexible structures and high-precision structures to meet long-range requirements for complex multibody platforms, spacecraft, and large scientific instruments.

During FY 1989, the revised Construction of Flexible Structures I structural flight hardware will be developed in preparation for a 1991 space experiment (requiring a 1990 delivery to Kennedy Space Center). Control sensors and actuators will be integrated into the structure, and ground tests will be conducted to establish control/structure response characteristics and for comparison with analytical predictions.

In addition, in FY 1989, the CSTI technology activity will continue to develop integrated control/structure analysis and design methodology and test methodology focused on selected structures, including the COFS I flight article. This will be a multicenter activity involving Langley Research Center, Marshall Space Flight Center, Goddard Space Flight Center, and the Jet Propulsion Laboratory and will be directed toward developing a NASA-wide approach to accelerate the design, development, and qualification of future large space structures.

High-capacity Power

The objective of this program is to develop the technology base for a nuclear power system capable of supplying high-capacity, long-life power for potential future sustained lunar and planetary base operations and any future evolutionary developments to the space station, and to supply power to electric propulsion systems for interplanetary cargo transfer vehicles. This is a joint activity with the Department of Energy (DOE) and DOD. The NASA program emphasis is on thermal-to-electric conversion, heat rejection, and power management and distribution subsystems. Higher conversion efficiencies in conjunction with improved thermal and power management and distribution systems materials and design innovations can enable a fivefold increase in the electrical power that can be delivered from the available thermal output of the SP-100 reactor, while more than doubling the system power-to-weight ratio.

During FY 1989, preliminary design of the Stirling space engine will be completed. After design review an approval, the detailed design efforts for the test engine(s) will be initiated, as well as test planning.

Technology development efforts for the power management and distribution system components will be increased, and a definition and assessment effort directed at fault-survivable power system concepts will be initiated in FY 1989. Research and technology tasks addressing the space environmental effects and interactions will also be conducted.

C. PATHFINDER—$60,000,000

The Committee authorizes $60 million for the Pathfinder program in FY 1989. This is $40 million less than the President's request. However, this account could be adjusted to reflect the $8 million general reduction for equipment and the $8 million increase for the Space Grant College and Fellowship Program. An amount of $20 million of the $60 million provided is earmarked for SP-100.

Summary of FY 1989 funding levels

Exploration Technology	$17,000,000
Operations Technology	41,000,000
Humans-In-Space Technology	13,000,000
Transfer Vehicle Technology	14,000,000
Mission Studies	15,000,000
Total Pathfinder	[1] $60,000,000

[1] Reflects a general reduction of $40 million. Also, this account could be further adjusted to reflect the $8 million general reduction or the $8 million augmentation.

Project Pathfinder is an important new program through which NASA will develop a broad set of technologies that will enable decisions on future space missions. Project Pathfinder is the critical next step, augmenting CSTI, in strengthening the technology foundation of the civil space program and the nation's technology leadership. Moreover, Pathfinder is an essential prerequisite to any future decision by the Nation's leadership to go forward with ambitious civil space missions. Pathfinder is organized into four technology areas: exploration, operations, humans-in-space, and transfer vehicles. In addition, mission studies will be conducted to support the detailed formulation of mission requirements and technology options. The technologies included in the exploration element are related to the gathering of scientific knowledge and technical understanding at mission sites on the Moon and Mars. The space operations element will address critical technologies for *in-situ* materials processing, fabrication, and assembly and repair of massive and complex systems in Earth orbit and at lunar and Martian orbits and surfaces. The humans-in-space program will address the technology for improving astronaut productivity, maintenance or health, with minimal or no dependence on resupply of expendables. The transfer vehicle element will support transportation to and from geostationary Earth orbit, the Moon, Mars, and other planets.

Exploration Technology

The essential technologies for the future robotics and piloted exploration of the Moon, Mars, and other planets in the solar system are grouped into four separate elements: planetary rover; sample acquisition, analysis, and preservation; surface power; and optical communications. The planetary rover element will focus on the development and integrated testing of technologies for mobility, navigation, site identification, and portable power. The sample acquisition, analysis, and preservation element will focus on the methodology for sample identification and selection, chemical and physical analysis, the development of special tools for sample acquisition, and sample preservation techniques. The surface power element will perform research leading to high power-to-weight, photovoltaic arrays, and regenerative fuel cells that are resistant to the dust, chemical reactants, and temperature environments ambient to the Moon and Mars. Optical communications hardware will be developed to support a subsequent flight demonstration at interplanetary distances.

In FY 1989, activities will be initiated in these technology areas.

Operations Technology

The space operations thrust will provide the critical technologies required for logistical support of human activities. For Earth orbit operations, this program will greatly extend our capabilities to maintain the infrastructure and to support major new science missions. For lunar and Mars missions, the critical technologies for preparing to depart Earth orbit, for performing tasks on lunar or Martian surface sites, and for safe return to Earth from those sites will be addressed. The specific program objectives include devloping the capability for *in-situ* lunar materials utilization, development of technology for advanced on-orbit operations, and the development of nuclear power for transportation and sustained lunar and planetary operations. Critical issues, such as the extent to which manned activities can be self-sustaining through processing of extraterrestrial materials, will determine the course of space exploration. The elements of the program include autonomous rendezvous and docking technology, resource processing pilot plant research, in-space assembly and construction, cryogenic fluid depot technology, and space nuclear power technology.

In FY 1989, activities will be initiated or continued in operations technology, including rendevous and docking, resource processing pilot plant research, in-space assembly and construction, cryogenic fluid depot, and space nuclear power (SP-100).

Humans-In-Space Technology

The objectives of the Human-In-Space Technology portion of the Pathfinder program are to enable: (1) on-demand, extended surface extravehicular activity (EVA) with mobility, dexterity, simple servicing and maintenance, and long-life systems; (2) productive cognitive and physical performance over long self-sufficient missions in different gravity environments and with protection from space radiation; and (3) self-sufficiency and significant reduction in life-support expendable weight and transport requirements for long missions (greater than one year). Existing technologies for these functions cannot be scaled to meet human performance and life-support requirements over long, self-sufficient missions. Furthermore, technology identification and advancement cannot effectively proceed without the determination of human performance and support requirements. This program will be conducted jointly with the Office of Space Science and Applications (OSSA). OSSA will determine the biomedical requirements and implement the life sciences portion of the program.

The objective of the EVA/suit program is to provide technology for a highly mobile, lightweight, rugged pressure suit and portable life support system that will allow safe and efficient EVA work during planetary missions. The objectives of the human performance program are to determine human capabilities, limitations, and adaptability for individual and group work during long-duration missions and to develop supporting human-machine interface technologies.

Finally, the objective of the closed-loop life support program is to provide a high degree of closure in the crew life support system for long/duration space missions to provide air revitalization, water reclamation, and waste treatment. Based on physical and chemical processes, highly efficient subsystems will be developed and integrated into a total life support system which will minimize the requirements for stored consumables and spares and eliminate the need for resupply.

In FY 1989, ENA suit system concepts will be assessed, life support processes will be modeled, and human performance mission-equivalent tasks will be developed and identified.

Transfer Vehicle Technology

Transfer vehicle technology addresses reusable transportation to and from geostationary Earth orbit, the Moon, Mars, and other destinations in the solar system. This thrust provides the technologies for a significant reduction in mission costs by reducing the mass required to be launched into low Earth orbit and in transit, as well as reductions in the transit time. The broad objectives toward these goals include research into higher performance, reusable, reliable, space-based transfer vehicles that have low operational cost. The efforts which support the objectives include chemical transfer propulsion, chemical vehicle propulsion, high-energy aerobraking, autonomous lander, and fault-tolerant systems technology.

In FY 1989, activities will be initiated in all of these key technology areas.

Mission Studies

Using the exploration scenarios identifed in Dr. Sally Ride's report, *Leadership and America's Future in Space,* as a starting point, the mission studies will: (1) identify other viable scenarios to be considered; (2) develop a more detailed definition of each of the candidate scenarios; (3) conduct trades and analyses of the scenarios to begin the process of narrowing down viable and desirable candidates; and (4) identify the prerequisites (technology, infrastructure, and precursor missions) for conducting such missions. Of critical importance are the long-lead technologies and infrastructure elements. Special emphasis studies will be conducted to investigate the high-leverage elements to identify the high-payoff options and critical technologies associated with these elements. These mission studies will serve to continually refine the Pathfinder technology program, ensuring that the critical and enabling technologies are receiving proper attention.

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In FY 1989 two-year parallel contracts of the more viable scenarios will be conducted focusing on conceptual design and definition studies. These parallel studies will define end-to-end mission scenarios and perform first-order systems trades, including mission unique functions, infrastructure (transportation, Space Station, and operating systems), and prerequisites (technology, science research, and precursors).

Finally, special emphasis studies will be developed through academia, industry, and other government agencies for definition of critical issues.

Space Research and Technology—Committee Comments

The Committee authorizes $350,900,000 for Space Research and Technology in FY 1989. This is $40 million less than the President's budget request and represents a $40 million reduction, without prejudice, to the Pathfinder Program—a proposed FY 1989 new start. The Committee also has earmarked $8 million of the Space Research and Technology Program for implementation of the Space Grant College and Fellowship Program initiated pursuant to Title II of P.L. 100–147 and has reduced the proposed equipment augmentation by $8 million.

The Committee continues to support a more vibrant research and technology capability within NASA and feels that such a program is critical to maintenance of U.S. leadership in space. The Committee also is well aware of the findings and recommendations of the National Research Council report on *Space Technology to Meet Future Needs,* and it agrees with the general thrust of this report—the United States does need to make a greater commitment to space research and technology.

It is because of these positions that the Committee's proposed reduction in the Pathfinder Program, a FY 1989 new start, is being made reluctantly. However, the Committee recognizes that the Pathfinder Program can be more easily redefined, rescheduled and slowed down at the outset of the program than at any other point of the program.

Despite the Committee's continued support of space research and technology, it was dismayed to discover that a significant percentage of the FY 1989 NASA budget request for the Pathfinder program was for activities already ongoing in FY 1988. The Committee thought NASA understood that when this situation occurred last year with the initiation of SCTI it was not to be repeated. The Committee hopes NASA thoroughly understands this issue now.

Concerning the Pathfinder Program, for FY 1989, NASA is instructed to allocate $20 million of the $60 million total recommended by the Committee for the Pathfinder Program for the SP–100 program, a critical element of the Pathfinder Program. This augmentation above the FY 1988 level and the terms and conditions of the existing NASA/DOE/DOD memorandum of understanding is intended to manifest the Committee's support of this initiative and commitment to sustained NASA participation.

The Committee also requests the Administrator of NASA to submit to the Committee by September 15, 1988, a report on NASA's need for advanced nuclear power sources, including a list of potential NASA missions and programs that require such sources, the type and level of power and capability required, and the proposed timing for development and deployment of such sources. The report shall address the role, projected budget, and program milestones of the SP-100 program, including an analysis of the relative roles and contributions of DOD and DOE to the SP-100 program.

The Committee, pursuant to its agreement with NASA, has earmarked $8 milion of the FY 1989 Space Research and Technology Program budget request for initiation of the Space Grant College and Fellowship Program. Based on inputs received during this year's Subcommittee field hearings, it is clear to the Committee that the availability of bright young scientists, engineers and technicians is critical to the ultimate success of the Nation's space program. Implementation of the Space Grant College and Fellowship Program, as well as a sustained commitment to ongoing activities, should help ameliorate the current situation.

Along this same line, the Committee applauds NASA's initiation and implementation of the University Space Research Engineering Research Centers Program. The fact that over 115 proposals were submitted in response to the agency's program announcement is indicative of the level of interest in the university community. The Committee strongly supports this initiative and NASA's efforts to use university-based centers as an integral part of the strategy to rebuild the nation's space technology base. The Committee assumes full funding in FY 1989, $16,300,000, for this program.

9. SAFETY, RELIABILITY AND QUALITY ASSURANCE—$22,400,000

The Committee authorizes $22,400,000 for Safety, Reliability and Quality Assurance in FY 1989.

Summary of FY 1989 funding level

Safety, Reliability, Maintainability and Quality Assurance	$22,400,000

The Safety, Reliability, Maintainability, and Quality Assurance (SRM&QA) program supports NASA's overall goals through activities in safety, reliability, quality assurance, maintainability, systems engineering, and program practices through independent assessment activities which reduce program risk. Specific objectives of the program are:

—To identify and provide independent assessment of issues that have potential impact on mission success.

—To support in-depth reviews, studies and analyses of issues and problems for readiness to launch.

—To conduct major tests and provide a viable problem reporting, corrective action, and trend analysis program throughout NASA.

—To perform radiation characterization on emerging technologies and complement the Air Force program for testing on-orbit radiation effects.

—To upgrade existing software standards, guidebooks, and training; and identify software management product assurance and automated work stations.

—To develop product assurance methodology for procuring reliable, custom large-scale integrated and very large-scale integrated circuit components.
—To upgrade technology and emphasize the safety, reliability and performance of NASA's aerospace battery power systems.
—To plan, document, and establish policy for a NASA-wide SRM&QA Information System.
—To increase the safety of high hazard operations and develop safety risk management policy and guidance for all NASA programs.
—To support industrial, aviation, fire protection, and ground operations safety activities.
—To provide policies, procedures and surveillance for all agency safety, quality, maintainability, and reliability activities.

In FY 1989, the SRM&QA program will continue to conduct activities in support of the objectives of NASA. This funding level will provide for enhanced capabilities which will implement the reporting and documentation of significant problems, assess problem resolutions and analyze trends, and other safety systems as required. NASA will develop a data base of failures, anomalies, and unsatisfactory conditions for analysis and assessment of remedial and preventive actions. Trend analysis of flight and critical ground hardware problems will be conducted, as well as for certain generic program hardware.

Problem reporting requirements, hazards analysis, and failure modes and effects analyses, accessible through an agency-wide tracking and reporting system, will continue to be supported in the Space Transportation Systems program through the Program Compliance Assessment Status Systems effort, and integrated engineering standards and practices will be implemented and a data base brought on-line.

The NASA safety program will increase the safety of hazardous operations, develop a better understanding of the failure modes of highly stressed wind tunnel components and pressure systems, and quantify the hazard potential of new, exotic propellants, existing cryogenic proplellants, and new composite materials. In addition, the Independent Systems Assurance Assessments program will develop between use of numerical techniques for reliability analysis and risk assessment.

Finally, the Non-Destructive Evaluation measurement assurance program will continue to provide state-of-the-art quantitative advanced inspection techniques for solid rocket motors, composites and ceramics and will explore inspection techniques such as microfocus X-ray, fiber optics, acoustic emission, computer tomography, and laser thermography.

Safety, Reliability and Quality Assurance—Committee Comments

The Committee provides $22,400,000 for FY 1989 for Safety, Reliability and Quality Assurance (SR&QA). This is the same as the President's budget request.

The Committee continues to support NASA's Safety, Reliability and Quality Assurance program and is committed to the reestablishment of this program as the hallmark of NASA. Between now and the next flight of the space shuttle, the Committee expects to be kept well informed by the SR&QA Office if any safety issues surface. The return to flight of a safe, reliable space shuttle is the highest priority of the Nation's civil space program, and the SR&QA Office, along with every individual associated with the shuttle program, must work to ensure a safe return to flight.

10. TRACKING AND DATA SYSTEMS—$18,800,000

The Committee authorizes $18,800,000 for Tracking and Data Systems in FY 1989.

Summary of FY 1989 funding levels

Advanced Systems	$18,800,000

The objective of the Advanced Systems Program is to perform studies and provide for the development of tracking and data systems and techniques required to obtain new, higher performance tracking and data handling capabilities that will address planned future mission requirements and also improve the cost effectiveness and reliability needed for overall support of the total mix of spaceflight missions.

Activities planned for FY 1989 include efforts to obtain location accuracies at the decimeter level for Earth-orbiting spacecraft which would make possible a new class of high precision Earth observatory missions on the Shuttle, Space Station and on free-flying spacecraft. The techniques being analyzed for particular application include the Department of Defense's Global Positioning System and the use of Very Long Baseline Interferometry. Work will continue on the development of extremely precise radiometric techniques for determining angular direction of future planetary missions to an accuracy of five nano-radians. Such improvements typically lead to improved spacecraft navigation and the conduct of science experiments not previously possible. Studies will continue on ground-based navigation strategies, analyses, and demonstrations for Galileo, Ulysses, and Mars Observer.

Tracking and Data Advanced Systems—Committee Comments

The Committee authorizes $18,800,000 for Tracking and Data Advanced Systems in FY 1989. This is the same as the President's budget request.

The Committee continues to support these activities that will improve the cost effectiveness and reliability of space missions.

II. SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS—$4,686,200,000

The Committee authorizes $4,686,200,000 for Space Flight, Control and Data Communications in FY 1989. This is $155 million less than the President's request.

The objective of the NASA program of space flight, control and data communications is to provide for the operational activities of the Space Transportation System (STS) and tracking and communication system support to all NASA flight projects. This objective is achieved through the following elements.

Shuttle Production and Operational Capability

This program is to provide a fully capable fleet of Space Shuttle orbiters, main engines, launch site and mission operations control requirements, initial spares, production tooling, and related supporting activities.

Space Transportation Operations

This program is to provide the standard operational support services for the Space Shuttle and the expendable launch vehicles. Within Shuttle operations, external tank and solid rocket booster flight hardware is produced; operational spare hardware is provisioned, overhauled and repaired, and manpower, propellants, and other materials are furnished to conduct both flight and ground (launch and landing) operations.

Space and Ground Network, Communications and Data Systems

This program is to provide vital tracking, telemetry, command, and data acquisition support to meet the requirements of all NASA flight projects. This support is currently provided by a worldwide network of NASA electronic ground stations interconnected by a communications system using ground, undersea, and satellite circuits. The Tracking and Data Relay Satellite System (TDRSS) will become the primary system for supporting upcoming Earth orbiting missions.

Summary of FY 1989 funding levels

Shuttle Production and Operational Capability	$1,335,500,000
Space Transportation Operations	2,365,400,000
Space and Ground Networks, Communication and Data Systems	985,300,000
Total Space Flight, Control and Data Communications	$4,686,200,000

The primary program objective of the current activity in the STS is to complete the safe return to Space Shuttle flight activities. The Space Shuttle is the key element of a versatile STS that is available to a wide variety of national users and certain international users. The Space Shuttle is the first reusable space vehicle and is configured to carry many different types of space apparatus, spacecraft scientific experiments, and national security payloads. In addition to transporting materials, equipment and spacecraft to orbit, the Shuttle offers unique capabilities that cannot be achieved with Expendable Launch Vehicles (ELV): retrieving payloads from orbit for reuse; servicing and repairing satellites in space; transporting to orbit, operating, and returning space laboratories; and performing rescue missions.

Shuttle Production and Operational Capability provides for the national fleet of Shuttle orbiters including the replacement orbiter which was fully funded in FY 1987. This budget element also provides for the launch site facilities, initial spares, production tooling, and related support activities. In addition, there is also included the design, test, analysis and certification associated with the recovery actions necessary, as a result of the Challenger accident, to verify the flight hardware and mission support processes necessary for returning to flight.

This line contains five subdivisions: Orbiter Operational Capability, Orbiter Replacement, Propulsion, Launch and Mission Support, and Changes and System Upgrades. Orbiter Operational Capability includes orbiter design modifications and system improvements, mission kits, procurement of a spares inventory for the operational orbiter fleet, necessary safety modifications identified by the NASA investigation and the Rogers Commission during the post-Challenger accident review process, initiation of a new set of structural spares to maintain the capability to produce orbiter vehicles, and continuation of work started in FY 1988 on an Extended Duration Orbiter (EDO) capability. Orbiter replacement will provide a replacement Orbiter for Challenger which is necessary to restore a significant element in the Nation's space launch capability. Propulsion Systems provides for Space Shuttle Main Engines (SSMEs), External Tank (ET), and Solid Rocket Booster (SRB) design improvements, safety modifications, capability investments, rate tooling and development of an Advanced Solid Rocket Motor (ASRM). Launch and Mission Support provides the Johnson Space Center (JSC) mission operations capability development, equipment provisioning of the facilities for launch and landing at the Kennedy Space Center (KSC) and the initial lay-in of spares and ground support equipment. Changes and Systems Upgrade provides funding for potential changes and systems modifications as well as for unanticipated new requirements not covered elsewhere.

Space Transportation Operations provides the standard operational support services for the Space Shuttle and ELVs for NASA payload requirements. Within Shuttle Operations, flight hardware is produced, refurbished and repaired; and manpower, propellants, and other materials are furnished to conduct and support both flight and ground operations. The Shuttle Operations program provides for the launch of NASA missions, DOD, other U.S. Government and certain commercial and international missions on a reimbursable basis. The launch schedule calls for one flight in FY 1988 (the first launch is scheduled for late summer 1988), seven flights in FY 1989, and ten flights in FY 1990.

The Shuttle provides launch services to non-NASA users on a reimbusable basis to satisfy DOD and civil government requirements. A limited number of foreign and commercial launches are planned following the resumption of flights based on administration policy decisions.

The ELV/Mixed Fleet plan provides launch services for unmanned civil U.S. government space missions not requiring the Space Shuttle's unique capabilities. Initially, ELV services will be procured, for selected high priority missions previously manifested on the Space Shuttle. Consistent with the Competition in Contracting Act, expendable launch vehicle services will be acquired from the U.S. private sector, where possible.

1. SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY—$1,335,500,000

The Committee authorizes $1,335,500,000 for shuttle production and operational capability in FY 1989. This is $65 million less than the President's request.

Summary of FY 1989 funding levels

Orbiter Operational Capability	$280,000,000
Launch and Mission Support	343,700,000
Propulsion Systems	711,800,000
Change and System Upgrading	0
Total Shuttle Production and Operational Capability	$1,335,500,000

The objectives of this program are to provide for the completion of the modifications required to return the STS to a safe flight status, the completion of the national fleet of Shuttle orbiters, including building a replacement orbiter for the Challenger; the development and production of the propulsion systems; the development of launch site capabilities; and the potential changes and upgrading of the STS. Also included is the development of the EDO and the ASRM.

Orbiter Operational Capability

The primary objective of this program is to continue the return of the three orbiter fleets to safe flight status in FY 1988. This will provide safe and reliable access to space for NASA, DOD and certain domestic and international users of space. In support of this objective, orbiter production activities include the necessary safety modifications identified by the Rogers Commission and the post-Challenger accident review process, as well as the development and installation of necessary hardware, software and procedural modifications. Also included will be the work necessary to continue work on an EDO capability.

In FY 1989, a new set of structural spares will be initiated in order to sustain the capability to produce another vehicle in addition to providing additional spares for inventory.

The procurement and fabrication of the orbiter spares inventory is ongoing. A concerted effort has been made to better define the spares requirements and production capability at various vendors. A logistics depot has been established at KSC for repair and maintenance of orbiter parts.

In FY 1989, Orbiter funds provide for the procurement of a logistics capability including an inventory of spares to support operations requirements, the continuation of previously approved systems improvement programs, necessary safety modifications identified as a result of the Challenger accident review process, initiating of the manufacture of a replacement set of structural spares, and the engineering analysis and integration support for the flight rate. Orbiter funding also provides for orbiter support activities such as the remote manipulator system, the on-board flight software, and implementation of a crew escape system during orbiter controlled gliding flight. Starting in FY 1989, work on the EDO will be continued under the orbiter program. In FY 1988, Congress appropriated funds in Research and Development to initiate the EDO.

In addition, the development, qualification and production of flight units for an improve auxiliary power unit (APU) and the upgrade of the general purpose computers (GPC) will continue. The orbiter funding also covers systems integration of all redevelopment analyses and hardware changes, as well as procuring orbiter support items and capability changes to the on-board flight software.

Replacement Orbiter

In order to provide assured access to space and to maintain U.S. preeiminence in space, NASA has been directed to procure a replacement orbiter (OV–105), with full funding provided in FY 1987. This replacement orbiter will provide a significant increase in existing National launch capability to fly off the backlog of national security, international, U.S. space industry, and NASA missions resulting from the Challenger accident.

Currently, a set of structural spares is being completed and used as the foundation for the production of OV–105. A contract has been signed with Rockwell International for the production of this orbiter; work began on August 1, 1987, and OV–105 is planned to be delivered in 1991.

Launch and Mission Support

This activity supports the development of launch and mission support capabilities, principally at JSC and KSC. A "second line" of facilities is provided in the launch site equipment budget to support processing and checkout of up to three orbiters in flow and to sustain the operational launches at KSC. In FY 1989, the third mobile launch platform will be completed.

Funding has been included for upgrading landing aids for end of mission and contingency/abort landing sites. Capability improvements have been added for weather prediction and information handling to improve system monitoring, notably for anomaly tracking. Funding for a pre-flight adaptor trainer has also been added to help prepare the crews for a weightless environment. Consistent with the recommendations of the Rogers Commission, improvements in simulation training including new host computers and interface hardware are being made. Other activities include implementing required modification and upgrades on the T–38 proficiency aircraft and procuring a fourth Shuttle Training Aircraft and a second Shuttle Carrier Aircraft. Procurement of extravehicular mobility unit (EMUS) and associated improvements are also included.

In FY 1989, Launch Site Equipment includes activities to improve the capability to support the flight rate requirements at KSC. The mission support capability requirements continue to establish an inventory of crew equipment, principally EMUs, to support the flight rate, and the mission operations capability funding in FY 1989 provides for completion of replacement of the host computers, selected critical items for the shuttle training simulators and replacement Advanced Data Processing (ADP) and other hardware in the Mission Control Center.

Propulsion Systems

Propulsion Systems provides for the production of SSMEs, the implementation of the capability to support operational requirements, and anomaly resolution for the SSME, SRB, and ET. The SSME program includes the production of the main engines required for the orbiter fleet, the procurement of spare engines, ground testing operations, development and certification activities to improve operating margins, reliability and durability, and anomaly resolution capability. The SRB program includes the reclamation and refurbishment of hardware produced prior to the Challenger accident, continued replacement of reusable hardware lost during the 51-L failure and subsequent ground testing of the SRB redesign, continuation of test data analyses and evaluation, completion of solid rocket motor (SRM) tooling modifications, procurement of transportation equipment to support the projected flight rate, and development of the ASRM. Engineering analysis and modification of booster hardware for certification of a 20 flight reuse capability will continue in FY 1989. Systems support primarily provides for support to the testing of the SSME in the main propulsion test article configuration.

The redesign of the SRB to resolve deficiencies in the previous design will be completed through certification and reflight in FY 1988. Assessment of flight data, including analysis and evaluation, will be continuing in FY 1989. There will be a continuing activity to improve tooling and procedures to enhance process control and product quality. Reclamation of reusable SRM hardware produced prior to the Challenger accident will be accomplished through static firing and refurbishment. Refurbishment of the case hardware will include modification to the redesigned configuration.

Funding for the FY 1989 budget is based upon resumption of the flight program in the late summer of 1988 (August/September time frame) and the design, test, and certification of the program and recertification of all flight hardware to assure compliance with flight requirements. The SSME program will continue production of flight hardware and the development programs including improvements to the current configuration and the alternate turbopump programs. The SRB FY 1989 funding will primarily focus upon continued evalution and analysis of flight data to assess thoroughly the redesign. Modification of booster hardware necessary to obtain a 20-flight reuse capability will continue as well. The ET program supports the production of tanks with required off-the-shelf equipment.

The ASRM project is intended to enhance the flight safety, reliability and performance of the Space Shuttle fleet. The ASRM will not be subject to the constraint of maximum utilization of existing hardware that limited changes on the recent SRM design activities. The ASRM may employ changes in configuration, design details, and materials to meet more stringent design requirements and enhance safety margins. Production processes will be examined to utilize the latest applicable technology and process automation to enhance reproducibility and reliability.

During the ASRM definition studies, now being conducted, the contractors will perform preliminary designs on a segmented motor and monolithic motor. Also, they will provide design data on a modern, automated production facility to maximize material and process controls for enhanced reliability. An additional objective of the ASRM is to achieve increased payload capability. The definition studies will examine achieving this objective with the requirement that there be no compromise to flight safety and reliability, and that the impact to other Shuttle elements be held to an absolute minimum.

The Request for Proposal (RFP) for the development phase will be issued at or near the end of the definition studies in the June/July period of 1988. One contractor is to be selected for developing, and the contract start is anticipated in January 1989. The development program is anticipated to extend for about 5 years with the first flight in early 1994. The development period is based on the original SRM development. The scope of the development will include modification or acquisition of facilities, the development and the test of the new design and production of verfication units. The ASRM development is comparable in scope and complexity to that of the SRM, and the technological base is greater than that at the start of the SRM project.

The asbestos-free installation development program previously included as a separate development will be incorporated into the scope of the ASRM development. This requirement is driven by environmental and production safety concerns rather than by technical or performance issues. Costly duplication of qualification tests can be avoided by incorporating this effort into the overall ASM. However, if the ASRM is not approved or the existing asbestos-based insulation production is stopped before the ASRM is available, the separate development will have to be reinstated.

Changes and systems upgrading

Management, technical flight experience, and cost review of the Shuttle program have stressed the need for providing an allowance for changes and modifications which inevitably are required in a large, complex, and technically demanding space system.

The Changes and Systems Upgrading budget provides for potential changes to improve system reliability, safety and performance.

The funding for fiscal year 1989 will provide for those changes which are considered to have the highest priority. The objectives are to improve reliability, increase operating safety margins, and reduce costs.

Space Shuttle Production and Operational Capability—Committee Comments

As was the case in FY 1988, restoring the space shuttle to flight status is the highest priority for NASA in FY 1989. Therefore, the Committee has provided $1,335,500,000 for Space Shuttle production and Operational Capability in FY 1989, including the Presidents full request of $88 million for development of an ASRM. The Committee's authorization is $65 million below the President's request. This represents a $40 million reduction to the space shuttle structural space program and a $25 million reduction to the Administrator's discretionary account for changes and system upgrading. The Committee is reluctant to recommend any reductions to this account because of the high priority given to return to flight of the space shuttle. Reductions, therefore, are recommended in the two accounts that do not affect those efforts.

Concerning the structural spaces program, the Committee recommends a funding level of $17,300,000 in FY 1989. This is an increase of $6,300,000 to the current program and should permit the prime contractor to retain critical subcontractor skills and to proceed with the critical spares—wins, orbital maneuvering subsystem (OMS) pods, feedlines, remote power controller among others.

The Committee is well aware of the arguments in support of the structural spares program and an option for a fifth orbiter. However, to bring the FY 1989 budget request in line with the realities of the congressional budget process, the Committee has recommended reductions in those activities not directly associated with the return-to-flight of the shuttle.

The Committee was pleased to see that the FY 1989 budget request included a new start for the ASRM facility. The Committee sees this initiative as a critical element of the space shuttle program and necessary for its enhanced safety, reliability and performance—a position that has been endorsed in two different reports of the National Research Council. The Committee, therefore, fully funds this program in FY 1989.

The Committee is concerned that NASA and OMB are still uncertain as to whether or not certain options in the ASRM request for proposals require legislation. To leave its options open, the Committee has included language in section 7 of the bill that permits continued discussions of this issue since it is the Committee's impression that enabling legislation would be required if option two or three were to be pursued. However, the Committee expects a formal notification on this matter from the administration as soon as possible.

The Committee also wants it to be perfectly clear that the Committee strongly endorses the ASRM program and feels that the request for proposals should be issued in a most timely manner so as to get this critical program under way. The Committee feels even more strongly that the selection criteria for the ASRM should be formulated by NASA alone and that the key criteria should be safety, reliability and performance.

The Committee also would like to indicate that it has been most pleased with NASA's efforts to keep the Committee informed of developments in the SRM test program, anomaly resolution activities, and return-to-flight issues. The Committee is pleased with NASA's methodology in selecting a crew escape system, with the involvement of the astronaut crops, and with the decision to incorporate the pole ejector into STS-26. The Committee also is pleased with the results of the Qualification Motor 6 full-scale test firing and anxiously awaits the results of the Qualification Motor 7 firing in June, the Production Verification Motor firing and the Flight Readiness Firing in July. The Committee still strongly adheres to the position that the successful implementation of these test firings is a necessary prerequisite to the return to flight of the space shuttle.

The Committee would like to reiterate its support of NASA's acquisition of a second space shuttle aircraft carrier, a fourth training aircraft and fourth orbiter.

In conjunction with the Spacelab program, the Committee is pleased to see NASA aggressively assessing the development of an EDO. The Committee strongly believes that an EDO could significantly enhance our Nation's space transportation infra-structure and that extended space shuttle flight duration could result in greater opportunities for space-based research and development. The Committee supports the $10 million allocation within the FY 1989 budget request for an EDO and recommends that NASA consider seriously including in the FY 1990 budget request a new start request and separate line item for an EDO.

Despite the fact that NASA's November 1987, *Report to the Congress on an Extended Duration Orbiter* substantiates the feasibility of an EDO, its relative value and cost, it provides a qualified, but not well documented, assessment of the feasibility of a commercial EDO venture and alludes to the fact that a commercial EDO might be less economically attractive than a government-developed EDO.

To better understand the relative merits of a commercial EDO vis-a-vis a government EDO, the Committee directs NASA to submit to the Committee by October 1, 1988, a report detailing the number and type of EDO options that are being assessed, the current status of these proposals, and the trade-off considerations between a government EDO program or commercial EDO venture. In light of the significant interest of this Committee and the administration in space commercialization, the Committee wants to be fully aware of these competing considerations before it renders a final opinion as to whether an EDO should be a government program or a commercial venture.

Finally, the Committee would like to recommend that NASA include a separate line item in the FY 1990 budget request for space shuttle spares. A separate line item for space shuttle spares would enable Congress to assess more accurately and thoroughly the role of these spares in the shuttle program and would highlight their importance to maintaining a robust space transportation system.

2. SPACE TRANSPORTATION OPERATIONS—$2,365,400,000

The Committee authorizes $2,365,400,000 for Space Transportation Operations in FY 1989. This is $40 million less than the President's requests.

Summary of FY 1989 funding levels

Shuttle Flight Operations	$660,100,000
Shuttle Flight Hardware	1,035,200,000
Shuttle Launch and Landing Operations	514,600,000
Shuttle Operations Subtotal	$2,209,900,000
Expendable Launch Vehicles and Services	155,500,000
Total Space Transportation Operations	$2,365,400,000

Space Transportation Operations provides launch services to NASA payloads utilizing a mixed fleet approach of the Shuttle and ELVs. Launch services are also provided, on a reimbursable basis to DOD, other civil agencies, and certain commercial and international users. The Shuttle program launch schedule is based on a resumption of flight activity in late summer 1988 with one flight in FY 1988, seven in FY 1989, and ten in FY 1990. The ELV planning reflects use of a mix of launch systems based on individual payload requirements.

The major program elements of Shuttle Operations are Flight Operations, Flight Hardware and Launch and Landing Operations.

These elements provide for the standard service operation of the Shuttle including pre-flight preparation activities, procurement and refurbishment of flight hardware and maintenance and operation of equipment and facilities necessary to support all phases of the Shuttle flight process.

The ELVs/Mixed Fleet plan was initiated in FY 1987 as a result of an assessment of NASA's space transportation requirements after the Challenger accident. This assessment showed that U.S. Civil Government spacecraft should be launched on a mixed fleet in order to provide increased access to space, to assure continuity of space operations, and to enhance mission flexibility. The missions currently planned for launch on ELVs are selected high priority missions previously manifested on the Space Shuttle for West Coast launches and selected East Coast launches which do not require the Shuttle's unique capabilities and can transition to ELVs without significant impact to the spacecraft.

Shuttle Flight Operations

Flight operations is divided into three major areas of activity: mission support, integration, and support. Mission support includes a wide variety of pre-flight planning, crew training, and operations control activities. The planning activities range from the development of operational concepts and techniques to detailed systems operational procedures and checklists. Whereas the integration activity includes orbiter sustaining engineering, payload integration into the Shuttle, system integration of the flight hardware elements, orbiter launch support services to the launch site and flight development and verification software. Finally, the support activity includes base operations support to Shuttle operations and systems level support at the manned space flight centers.

Currently, the resources for Flight Operations are focused upon preparing for resumption of flight, correcting a backlog of system discrepancies and incorporating a large number of changes to ground systems, hardware, software, and procedures including those resulting from the ongoing process of analysis and decision-making in the wake of the Challenger accident. Flight preparation, training of ground and flight crews (including system-wide integrated simulations), and other functions are being carried out. These efforts are critical to the safe operation of the Shuttle and significant emphasis is being placed on insuring that the flight products and crew training satisfying revised and more stringent operational requirements.

In FY 1989, the Flight Operations portion of the Shuttle Operations budget continues to support that activity predominately associated with the effort at JSC to plan for and conduct STS missions from launch to landing. The functions are essentially the same as in the past: to maintain and operate all the ground facilities necessary for flight preparation and execution, and to instruct the flight and ground controller crews; to maintain and operate aircraft for proficiency, training and orbiter ferry requirements and to perform analyses of and conduct of the mission planning necessary for each mission.

Shuttle Flight Hardware

The Flight Hardware program element provides for the procurement of ETs, the manufacturing and refurbishment of SRB hardware and motors; and operational support to the Orbiter including orbiter spares, ET disconnects, spare components and flight support for the SSMEs and maintenance and refurbishment of flight crew equipment.

In FY 1989, requirements for Orbiter flight spares, crew equipment spares, and logistics are based on projected flight rates, maintenance schedules, operational usage, repair times, and lead times to procure or repair flight hardware.

The budget provides replenishment line and shop replaceable units, as well as the manpower to support the overhaul and repair activity for the Orbiter, the EMU and other crew equipment. The flight equipment processing contract (FEPC) which was initiated during FY 1986 is continuing its buildup to full capability to support the projected flight rates. SSME hardware provides for manufacturing and delivery of overhauled engines, engine component spares and flight support. Flight hardware requirements activity for the SRB and ET include the procurement of the materials and labor required for refurbishment and fabrication of units which will be flown during FY 1989, as well as the support of the production of units which will be flown thereafter. Additionally, two static firing tests of the redesigned SRM will be conducted to monitor the consistency of production characteristics.

Shuttle Launch and Landing Operations

Launch and Landing Operations provides for the manpower and materials to process and prepare the Shuttle flight hardware elements for launch as they flow through the processing facilities at KSC.

Operation of the launch and landing facilities and equipment at KSC is the primary function of the Shuttle Processing Contractor (SPC). This includes stacking and mating of the flight hardware elements into a launch vehicle configuration, verification of the launch configuration, and operation of the launch processing system prior to lift-off.

Support to Shuttle processing is provided by the Base Operations Contractor (BOC). The BOC is responsible for operations support functions such as propellants and life support, railroad maintenance, pressure vessels, Shuttle landing facility and facility and equipment modifications.

The Payload and Ground Operations Contract (PGOC) is the major contract for the payload processing activities. In Shuttle Operations, the PGOC contractor provides the standard service processing of all STS payloads into an integrated cargo prior to loading into the Shuttle. PGOC will also be the primary contractor for Spacelab and Space Station payload processing at KSC, funded under their respective budgets.

Launch operations funding in FY 1989 provides for manpower and support services necessary for processing launches from KSC. Funding also supports the manpower required for sustaining engineering, spares provisioning, logistics, launch processing system operation and maintenance, and maintenance/modification of all other shuttle-related ground support equipment and facilities. Flight safety will continue to be emphasized through testing, engineering and quality control.

Payload and launch support funding provides propellants for launch operations, base support and contractor support for the assembly of individual payloads into a total cargo.

Expendable Launch Vehicles/Mixed Fleet

The ELVs/Mixed Fleet plan, initiated in 1987, provides launch services for selected NASA payloads not requiring the Space Shuttle's unique capability. Four performance classes of expendable vehicles are planned in the mixed fleet. A small class capable of launching payloads up to 1,000 pounds into low Earth orbit; a medium class capable of launching payloads up to 10,000 pounds into orbit; an intermediate class capable of launching payloads up to 30,000 pounds; and a large class capable of launching payloads of 40,000 pounds or more. NASA plans to utilize competition where possible in the acquisition of ELV services in these performance classes to accommodate a range of spacecraft requirements in FY 1992 and beyond. In the interim, NASA will acquire expendable launch vehicle services for selected high priority missions previously manifested on the Space Shuttle consistent with the Competition in Contracting Act (CICA). In this interim period, two Delta II launches, one for the Roentgen Satellite (ROSAT) and one for the Extreme Ultraviolet Explorer (EUVE) are being acquired through DOD. DOD has also been requested to provide a Titan IV vehicle to be available in 1991 to provide a back-up for either the Magellan, Galileo or Ulysses planetary missions presently manifested on the Shuttle. Titan III vehicles are being evaluated for launch of the TDRS-F and Mars Observer spacecraft in the 1991/92 time period. In addition, discussions are in progress to obtain Atlas/Centaur Launch services for the Combined Release and Radiation Effects Satellite (CRRES) as part of a barter in exchange for residual hardware from previous programs. Assuming that CRRES is launched on this vehicle, several of the planned experiments which could not be accommodated on Atlas/Centaur would be launched on Scout vehicles.

In FY 1989, funds are required for continuation of launch vehicle procurements through the DOD for the ROSAT and the EUVE missions. In addition, funding is required to initiate work on the Titan III, Titan IV, Atlas/Centaur and Scout launches described above. Funding is required for medium class vehicles for the Geotail and Wind spacecraft of the Global Geospace Science project. Procurement of launch services for small class vehicles in support of Science and Application missions, planned to be launched at a rate of two per year, will be initiated with these funds.

Space Transportation Operations—Committee Comments

The Committee authorizes $2,365,400,000 for Space Transportation Operations in FY 1989. This is $40 million less than the President's budget request. This reduction, as described below, is applied to the ELVS line item. As was the case with the Space Shuttle Production and Operational Capability account, the Committee recommends no reductions to any space shuttle return to flight activities.

The Committee anxiously awaits the launch of STS-26 and the resumption of a regular flight schedule by NASA. It is with great concern, therefore, that the Committee acknowledges the explosion of the Pacific Engineering and Production Company plant in Henderson, Nevada on May 4. The Committee has received the preliminary briefings on the possible ramifications of the loss of this source of a critical component of the SRB propellant and its impact on the proposed space shuttle flight rate. The Committee anxiously awaits the findings of the National Security Council (NSC) Task Force that is assessing this issue and has added language to the authorization for space transportation operations to give NASA maximum flexibility in dealing with this matter. The Committee appreciates NASA's cooperation in this matter and expects to work closely with NASA and the NSC to formulate a reasonable response.

As regards the Committee's reduction of the ELV budget request, it should be noted that the Committee still strongly supports the mixed fleet concept. However, due to the severe budget constraints in FY 1989, the Committee cannot increase the program from its current level of funding, $28 million, to the requested level of funding, $195,500,000. The Committee has authorized $155,500,000 million in FY 1989. This should permit the aggressive acquisition of Scout- and Delta-class vehicles, a commercial Titan III for the Mars Observer, and initiation of the acquisition of a Titan IV, planetary backup. The Committee has deferred a decision on a second Titan III until FY 1990 and assumes a general reduction of $25 million.

3. SPACE AND GROUND NETWORKS, COMMUNICATION AND DATA SYSTEMS—$985,300,000

The Committee authorizes $985,300,000 for Space and Ground Networks, Communications and Data Systems in FY 1989. This is $50 million less than the President's request and reflects a general reduction of $50 million.

Summary of FY 1989 funding levels

Space Network	$538,900,000
Ground Networks	248,100,000
Communications and Data Systems	248,300,000
Total Space and Ground Networks, Communication and Data Systems	[1] $985,300,000

[1] Reflects a general reduction of $50 million.

The purpose of this program is to provide vital tracking, telemetry, command, data acquisition, communications and data processing support to meet the requirements of all NASA flight projects. In addition to NASA flight projects, support is provided on a reimbursable basis for projects of DOD, other government agencies, commercial firms, and other countries and international organizations engaged in space research.

Support is provided for Earth orbital, planetary and solar system exploration missions, research aircraft, sounding rockets and balloons. Tracking and acquisition of data for the space projects is presently accomplished through the use of a worldwide network of NASA ground stations, and by the first of three tracking and data relay satellites (TDRSS) in geosynchronous orbit working with a highly specialized ground station. Ground facilities are interconnected by terrestrial and communications satellite circuits linking the spacecraft and their control centers for execution of the missions.

To meet the support requirements levied by the wide variety and large number of flight projects, NASA has three basic support capabilities to meet the needs of all classes of NASA flight missions. These are the Spaceflight Tracking and Data Network (STDN), which supports Earth orbital missions; the Deep Space Network (DSN), which primarily supports planetary and interplanetary flight missions; and the Space Network, including the Tracking and Data Relay Satellite System (TDRSS), which will provide all low Earth orbital mission support when it becomes fully operational.

Space Network

The Space Network consists of the TDRSS and a number of NASA ground elements to provide the necessary tracking, telemetry, command, and communications services to low Earth orbital spacecraft. The TDRSS, when fully operational, will consist of a three satellite constellation, including an on-orbit spare, in geostationary orbit and ground facilities located at White Sands, NM. From the White Sands location, satellite and ground comunications links interconnect the NASA elements of the network and any remotely located user facilities.

The FY 1989 request includes funding for: repayment of the loans extended by the Federal Financing Bank for TDRSS development; maintenance and operation of the White Sands complex and other NASA elements of the network; support activities such as systems engineering, documentation and mission planning; equipment modification and replacement; analytical studies to define the spacecraft required for the next generation TDRSS; the development and integration of an additional spacecraft to replace the TDRS lost in the Challenger accident; and the implementation of a second TDRSS ground terminal at White Sands.

In FY 1989, the space network budget request would provide for continuation of the construction phase of an optional TDRS spacecraft to replace the satellite lost in the Challenger accident. It also would permit selection of a single contractor for implementation of a second TDRSS ground terminal and initiation of definition activities for an advanced tracking and data relay satellite to meet future mission requirements.

Ground Networks

The Ground Networks provide support to three broad categories of missions: Earth orbital spaceflight; planetary and solar system exploration; and aeronautics, balloons and sounding rockets. Earch orbital support is provided primarily by the STDN, a network of eight geographically dispersed ground stations. The Deep Space Network, with ground stations located at three sites approximately 120 degrees apart in longitude, provides support to the planetary and solar system exploration missions as well as Earth orbital missions not compatible with TDRSS. Aeronautics, balloons and sounding rocket research are supported by specially instrumented ranges, as well as mobile systems.

Funding for the Ground Networks provides for operation and maintenance of the worldwide tracking facilities, engineering support, and the procurement of hardware and software to sustain and modify network capabilities as required to support new missions. The workload in FY 1989 will include support to the Space Shuttle, the Voyager-2 encounter with the planet Neptune, and the Magellan spacecraft launch. Magellan will perform radar imaging of Venus during FY 1990. Preparations will be under way for the future Galileo, Ulysses, and Mars Observer planetary encounter missions, and the Global Geospace Science (GGS) mission. Ongoing missions such as Dynamic Explorer (DE), International Ultraviolet Explorer (IUE), and Solar Maximum Mission (SMM) will continue to receive Ground Networks and/or Space Network support. Aircraft test programs will also be supported.

Communications and Data Systems

Funds requested for the Communications and Data Systems program provide for the implementation and operation of facilities and systems which are required for data transmission, mission control and data processing support.

Communication circuits and services provide for the transmission of data among the remote tracking and data acquisition facilities, launch areas, and the mission control centers. Real-time information is crucial to determine the condition of the spacecraft and payloads for the generation of spacecraft and payload control commands. Data received from the various spacecraft must be processed into a usable form for spacecraft monitoring in the control centers and before the transfer of data to the experimenters. Missions supported include Shuttle, Spacelab, NASA scientific and application projects, and international cooperative efforts.

Major activities under way include: implementing necesary changes to the Hubble Space Telescope mission control and data capture system, and misson control and data processing capabilities required to support upcoming missions such as Gamma Ray Observatory (GRO), Sapcelabs, Upper Atmosphere Research Satellite (UARS), GGS and Advanced X-ray Astronomy Facility (AXAF). In addition, studies are continuing to evaluate Space Station support requirements.

Space Tracking and Data Acquisition—Committee Comments

The Committee authorizes $985,300,000 for Space Tracking and Data Acquisition in FY 1989. This is $50 million less than the President's request.

The Committee is most supportive of the Space Tracking and Data Acquisition program and is well aware of its importance to the operation of the Nation's space program. However, to distribute equitably the proposed reduction to the FY 1989 NASA budget request, the Committee recommends a general reduction of $50 million from this account. The Committee anticipates that NASA can spread this reduction efficiently and economically and with minimum impact to the acquisition of a replacement TDRS and to the initiation of development activities for a second TDRS system ground station.

The high priority status of the Space Tracking and Data Acquisition program is reflected by the fact that two of the first three payloads scheduled for launch on the space shuttle are tracking, data and relay satellites. The Committee, therefore, intends to work closely with NASA to insure the timely deployment of these satellites and the timely development of the necessary space tracking and data relay infrastructure.

III. CONSTRUCTION OF FACILITIES—$260,100,000

The Committee authorizes $260,100,000 for Construction of Facilities in FY 1989.

The Construction of Facilities (COF) appropriation provides contractual services for the report, rehabilitation and modification of existing facilities, the construction of new facilities; the acquisition of related facility equipment; the design of facilities projects; and advanced planning related to future facilities needs.

The funds requested for FY 1989 provide for the continuation of prior year endeavors in meeting the facilities requirements for the Space Flight and Space Station programs; initiating of a structured multi-year effort to restore and modernize NASA's aeronautical research and development facilities; repair, rehabilitation and modification of other facilities to maintain, upgrade and improve the usefulness of the NASA physical plant; minor construction of new facilities, facility planning and design activities, and environmental compliance and restoration.

The projects and amounts in the budget estimates reflect Space Station and Space Flight requirements that are time-sensitive to meet specific program objectives. Other programs requirements for 1989 include construction of an auxiliary chiller facility at the Johnson Space Center; modifications to the X-ray Calibration Facility to support the Advanced X-Ray Astrophysics Facility Program at the Marshall Flight Center; modernization of the Space Environment Simulator and modifications for utility reliability at the Goddard Space Flight Center; refurbishment of the 25-Foot Space Simulator at the Jet Propulsion Laboratory; projects to repair, restore and modernize NASA's aeronautical research and development facilities at Ames, Lewis, and Langley Research Centers; and refurbishment of the Electric Power Laboratory at the Lewis Research Center.

The FY 1988 program continues to meet the objectives of preserving and enhancing the capabilities and usefulness of existing facilities and ensuring safe, economical and efficient use of the NASA physical plant. This request continues the necessary rehabilitation and modification program begun in prior years and continues a repair program. The purpose of the repair program is to restore facilities to a condition substantially equivalent to their originally designed capability. The minor construction program continues to provide a means to accomplish smaller facility projects which accommodate changes in technical and institutional requirements. The Environmental Compliance and Restoration Program will ensure that statutory environmental requirements will be met and any necessary remedial action promptly taken.

Funds requested for facility planning and design cover advance planning and design requirements for potential future projects, master planning, facilities studies, engineering reports and studies and the preparation of facility project design drawings and bid specifications.

Summary of FY 1989 funding levels

(1) Modifications to Processing Technology Facility for Space Station, Marshall Space Flight Center	$3,700,000
(2) Construction of Addition for Space Systems Automated Integration and Assembly Facility, Johnson Space Center	9,200,000
(3) Replacement of High Pressure Gas Storage Vessels, National Space Technology Laboratory	3,500,000
(4) Increase Chiller Capacity, LC-39 Utility Annex, Kennedy Space Center	2,300,000
(5) Rehabilitation of Pad A, LC-39, Kennedy Space Center	4,600,000
(6) Refurbish Atmospheric Reentry Materials and Structures Evaluation Facility, Johnson Space Center	4,900,000
(7) Modification for Advanced Engine Development, Test Stand 116, Marshall Space Flight Center	13,500,000
(8) Modifications to Orbiter Modification and Refurnishment Facility for Safing and Deservicing, Kennedy Space Center	2,800,000
(9) Modification to the X-Ray Calibration Facility, Marshall Space Flight Center	11,400,000
(10) Construction of Auxiliary Chiller Facility, Johnson Space Center	7,800,000
(11) Modernization of Space Environment Simulator, Goddard Space Flight Center	2,800,000
(12) Modifications for Utility Reliability, Goddard Space Flight Center	3,100,000
(13) Refurbishment of 25-Foot Space Simulator, Jet Propulsion Laboratory	12,000,000
(14) Repair and Modifications of 12-Foot Pressure Wind Tunnel, Ames Research Center	36,500,000
(15) Rehabilitation and Modifications to 10×10 Supersonic Wind Tunnel, Lewis Research Center	14,500,000
(16) Refurbishment to Hypersonic Facilities Complex, Langley Research Center	12,800,000
(17) Refurbishment of Electric Power Laboratory, Lewis Research Center	6,100,000
(18) Construction of National Resource Protection at various locations	2,600,000
(19) Repair of facilities at various locations, not in excess of $750,000 per project	27,000,000
(20) Rehabilitation and Modification of Facilities at various locations, not in excess of $750,000 per project	34,000,000
(21) Minor construction of new facilities and additions to existing facilities at various locations, not in excess of $500,000 per project	9,000,000
(22) Environmental compliance and restoration	26,000,000
(23) Facility planning and design not otherwise provided for	20,000,000
Total Construction of Facilities	[1] $260,100,000

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[1] Reflects a general reduction of $10 million.

Construction of Facilities—Committee Comments

The Committee authorizes $260,100,000 for Construction of Facilities in FY 1989. This is $25 million less than the President's request. This reduction consists of the deferral of the Space Station Processing Facility at the Kennedy Space Center, without prejudice, until FY 1990 (−$15 million) and a general reduction of $10 million.

The Committee was most pleased with the recommendations of the *Major NASA Wind Tunnel Revitalization Program* report and strongly endorses the proposed FY 1989 construction of facilities. The repair and modification of the 12-foot pressure wind tunnel at Ames, the rehabilitation and modernization to the 10x10 supersonic wind tunnel at Lewis, and the refurbishment of the hypersonic facilities complex at Langley are high priority projects that will help the United States retain its technological leadership in aeronautics.

The Committee realizes that these three wind tunnel initiatives are only the first steps of a much larger program. But the Committee is prepared to support NASA in this effort and to restore, rehabilitate and modernize these valuable assets.

IV. RESEARCH AND PROGRAM MANAGEMENT—$1,880,000,000

The Committee authorizes $1,800 million for Research and Program Management (R&PM) in FY 1989. This is $35 million less than the President's request.

The R&PM appropriation funds the performance and management of research, technology and test activities at NASA installations and the planning, management and support of contractor research and development tasks necessary to meet the Nation's ongoing objectives in aeronautical and space research. The objectives of the activities funded by the R&PM appropriation are to; (1) provide the civil service staff with the technical and management skills to conduct the full range of programs for which NASA is responsible, (2) provide base maintenance of facilities and manage its use in support of research and development programs, and (3) provide effective and efficient technical and administrative support for the research and development programs.

The 1989 R&PM appropriation request provides funding for the 22,950 permanent and temporary civil service work years (FTE) at eight major installations and Headquarters. This civil service work force is NASA's most important resource and is vital to future space and aeronautics research activities. At the direction of the Committees on Appropriations, NASA, beginning in 1988, has realigned the R&D/SFCDC and R&PM appropriation structures. In the realigned R&PM appropriation, about 59 percent provides for the salaries and related costs of the civil service work force. Three percent is for travel, critical to manage successful NASA's in-house and contracted programs. The remaining amount of the R&PM appropriation provides for the research, test and operational facility support, and for related goods and services necessary to operate efficiently and effectively the NASA installations and to accomplish NASA's approved missions.

NASA field centers report to the Program Associate Administrator responsible for the major portion of their technical programs. The principal roles assigned to each installation, based on demonstrated capabilities and capacities to meet NASA's overall program goals, are as follows:

Office of Space Flight

Johnson Space Center.—Management of the Space Shuttle program, including orbiter production and operation: selection and training of astronauts and mission specialists; Space Transportation System Operations, including mission planning, operational procedures and flight control; and management of the Space Station Truss system, airlocks and nodes, subsystems development, including propulsion and extravehicular activity, and operations planning and definition.

Kennedy Space Center.—Launch of Space Shuttle flights: management of the ground operational phase of the Space Transportation System; the preparation and launch of payloads on the Space Shuttle and expendable launch vehicles, and Space Station operational readiness planning.

Marshall Space Flight Center.—Management of the Space Shuttle main engine, solid rocket booster and external tank projects; management of NASA's activities on the Spacelab project: management of large automated spacecraft projects such as the Hubble Space Telescope; conduct and development of experiments in materials processing in space; and management of the Space Station habitation, logistics and laboratory modules.

National Space Technology Laboratories.—Space Shuttle engine testing; Earth resources research and technology transfer; and provision of support service functions for other government agencies located on site.

Office of Space Science and Applications

Goddard Space Flight Center.—Development and operation of Earth orbital flight experiments and automated spacecraft to conduct scientific investigations and demonstrate practical applications; management of tracking and data acquisition activities; management of the Delta launch vehicle program; management and launch of sounding rockets and balloons; operation of an instrumented flight range of aeronautical and space research; and development of the Space Station platforms and payload accommodations. The Wallops Flight Facility is an operational element and component installation of the Goddard Space Flight Center.

Office of Aeronautics and Space Technology

Ames Research Center.—Conduct of activities involving experimental and theoretical aerodynamics research, computational fluid dynamics, aeronautical flight research and testing, rotocraft technology, short and vertical takeoff and landing technology, technology for transatmospheric vehicles, planetary probe research, life sciences, human factors, autonomous systems, guidance and control, and operation of an alternate landing site for the Space Shuttle operational missions. The Dryden Flight Research Facility, an operational element and component installation of Ames located in the Mojave Desert, is the site of advanced flight testing and shuttle landings.

Langley Research Center.—Conduct of subsonic aircraft research and technology, emphasizing fuel conservation, safety and environmental effects; hypersonic propulsion; experimental and theoretical aerodynamics; environmental quality monitoring by remote sensing; advanced space systems technology; and research in the areas of structures and materials, guidance and controls, and airframe/propulsion integration of the transatmospheric research and technology program.

Lewis Research Center.—Conduct of aeronautical and space propulsion research and technology, including propulsion for the transatmospheric research and technology program; space communications research and technology; space energy systems research and technology; development of the space station power system; and management of expendable launch vehicle programs.

The 1989 budget provides the necessary resources to apply these in-house capabilities to program activities. A summary description of, and the funding required by functional category, include:

1. *Personnel and Related Costs.*—Includes salaries and benefits, the government's contribution to personnel benefits for NASA permanent and temporary civil service employees (including the government's cost of the Federal Employees Retirement System (FERS) and the Civil Service Retirement System (CSRS)), and for personnel of other government agencies detailed to NASA. In 1989, the cost of an additional 525 FTE is included. The additional FTE will complete the staffing requirements for space transportation system recovery and strengthen further the NASA Inspector General staff. This category also includes other personnel related costs, such as moving expenses (excluding the associated travel of people), recruiting and personnel investigation services provided by the Office of Personnel Management, and the training of NASA civil service employees.

2. *Travel.*—Includes the cost of transportation, per diem, and related travel expenses of civil service employees who travel for the direction, coordination and management of NASA program activities, including overseas launch and tracking sites; for contract management; for flight mission support; for meetings and technical seminars and symposia; and for permanent and temporary relocations.

3. *Operation of Installation.*—Provides a broad range of services, supplies, and equipment in support of each center's institutional activities. These are divided into three major subfunctional areas: Facilities Services, covering the cost of rental of real property, maintaining and repairing institutional facilities and equipment, and the cost of custodial services and utilities; Technical Services, covering the cost of automatic data processing for management activities, and the cost of educational and informational programs and technical shops supporting institutional activities; and Management and Operations, covering the cost of administrative communications, printing, transportation, medical, supply and related services. The realignment of appropriation structures in 1988 affected the Operation of Installation portion of R&PM. The amounts by major subcategory are as follows:

A. *Facilities Services.*—Includes rental of real property; the cost of maintenance, repair and related activities for facilities and equipment; custodial services; minor modifications and alterations; and utilities services.

B. *Technical Services.*—Includes the cost of general purpose automatic data processing for management activities (including development of agencywide automated systems); education and informational programs; other essential technical services.

C. *Management and Operations.*—Includes the cost of administrative communications; printing and reproduction; Administrative supplies; general purpose materials and equipment; transportation of equipment and supplies (including payments to interagency motor pools); medical services and other support.

Summary of FY 1989 funding levels

Personnel and Related Costs	$1,131,008,000
Travel	51,000,000
Operation of Installation	732,992,000
Facilities Services	(302,588,000)
Technical Services	(183,958,000)
Management and Operations	(246,446,000)
Total Research and Program Management	[1] $1,880,000,000

[1] Reflects general reduction of $10 million

Research and Program Management—Committee Comments

The Committee authorizes $1,880 million for R&PM in FY 1989. This is $35 million less than the President's budget request. The proposed reduction is a general reduction to be spread efficiently and economically by NASA.

The Committee has long believed that NASA's key asset has been its talented and dedicated managers, scientists, engineers and support staff. However, the Committee is concerned that not enough emphasis has been placed by NASA or the Congress on developing the next generation of qualified scientists and engineers or on retaining the current generation.

So concerned is the Committee that this year it held a field hearing in Wichita, KS to explore this and other issues related to the future competitiveness of the United States. Not all the answers were positive. There are trends in the scientific and engineering community that are alarming. Clearly, corrective measures must be taken now if the situation is to be improved and if these talented young engineers, scientists and technicians are to be attracted to employment in the Federal government.

First, NASA must have an exciting mix of programs and missions. The challenge and rewards of public service must help compensate for any pay disparity that might exist between the public and private sectors.

Second, NASA must expand its educational outreach activities and fellowship programs. The recently implemented NASA University Space Engineering and Research Program is a step in that direction, as will be the implementation of the National Space Grant College and Fellowship Program. These programs are critical to the success of NASA and the civil space program and require greater focus and attention. To help highlight these programs, the Committee strongly urges NASA to create a separate line item and a detailed description of educational programs in the FY 1990 budget submission.

Third, there is a clear and compelling need to reexamine the existing Federal personnel system to see what changes and improvements could be made to retain and attract people with the necessary technical and managerial capabilities to NASA. Along this line, the Committee has been working closely with the Senate Governmental Affairs Committee on legislation to implement a demonstration program in NASA using an alternative compensation system. This legislative proposal has progressed rapidly, and the Committee is hopeful that floor action will occur on such a measure this summer.

However, in addition to the people-resource issue, there are very real near-term issues that could seriously affect NASA. The fact that action on a proposed FY 1988 supplemental appropriations bill apears to have ceased is cause for concern, since it includes transfer authority for NASA to remedy a possible personnel problem brought on by the significant reductions in the FY 1988 Continuing Resolution (P.L. 100-203). The Committee is hopeful that the FY 1989 HUD-Independent Agencies Appropriations Bill can be enacted in time to give NASA this necessary authority.

The Committee also is concerned that NASA might again be trying to do too much with too few resources—in particular, people. The fact that NASA requested an augmentation of nearly 2,100 full-time equivalent slots in FY 1989 from OMB and only got 525 is cause for concern. The Committee also is alarmed about reports that NASA Center Directors' requests for additional people—people critical to the safe and reliable return-to-flight of the space shuttle—cannot always be provided.

The Committee has fully endorsed the Administration's request for 525 new civil service positions in FY 1989. However, the Committee realizes that with the proposed FY 1989 NASA program mix, the augmentation of 525 positions will not be enough. The fact that NASA and OMB are currently reviewing a possible FY 1989 augmentation of personnel for the space station program highlights the Committee's concern.

The Committee, therefore, instructs NASA to submit to the Committee by March 15, 1989, a five-year personnel plan for NASA. This plan should include NASA's best estimate of personnel requirements—civil service and contractor personnel—for the period FY 1990-94 and the estimated budget requirements. This report also should indicate how these personnel requirements will be allocated to the individual programs.

Consistent with its actions in the FY 1988 NASA Authorization Bill, the Committee earmarks $250,000 of the funds authorized for R & PM for activities associated with organizing the national and international aspects of the International Space Year (ISY). These monies are to be divided equally between NASA's Office of External Relations and the Office of Space Science and Applications.

The Committee also would request that NASA submit a project status report for each of the major NASA parograms included in the FY 1990 budget request by March 1, 1989. The Committee has found these documents to be a most useful tool in formulating the authorization bill and would would like to see these reports continued.

Finally, the Committee is concerned that certain activities, which are clearly NASA tasks, are being done occasionally by NASA contractors. This would include assistance with preparation of testimony, reports, and answers to questions posed by Congressional Committees. The Committee supports contracting out when the service rendered can be done more efficiently and economically by a private sector operation than a Federal operation. However, when it is done to augment staffing capability, impaired by caps on hiring, the Committee has concerns. The Committee has yet to explore this matter to a degree where it can make any substantive recommendations. However, the Committee does intend to explore this issue.

Amendment to National Aeronautics and Space Act of 1958 To Authorize Warrantless Arrests Under Certain Circumstances By Designated Personnel—Section 8

Presently, section 304(e) of the National Aeronautics and Space Act of 1958 provides the authority for certain NASA personnel as well as certain employees of contractors and subcontractors to carry firearms in the fulfillment of their official duties.

This amendment to section 304 of the NASA Space Act, specifically a new subsection (f), would provide the authority to arrest without warrant to NASA employees designated by the Administrator as well as those contractor and subcontractor personnel carrying out their official duties while guarding and protecting property of the United States under the administration and control of NASA or its contractors or subcontractors.

Subsection (e) and new subsection (f) when read together would allow certain NASA personnel, as well as certain subcontractor and contractor personnel, to make an arrest for the violation of Federal, and in some instances State laws, occurring on NASA property or involving property owned by or in the custody of NASA if the person has reason to believe that the person to be arrested has committed or is committing a felony. Security personnel shall use the minimum degree of force, including firearms, necessary to effectuate the arrest. NASA will develop regulations to be approved by the Administrator and the Attorney General before this authority will be exercised.

The authority is consistent with that granted to DOE pursuant to 42 U.S.C. 2201(k).

John C. Stennis Space Center—Section 9

Section 9 incorporates the provisions of S. 2216, a bill to designate the National Space Technology Laboratories in Bay St. Louis, MS, as the "John C. Stennis Space Center." S. 2216 was introduced by Senator Cochran on March 25, 1988.

The Committee included this provision as a just and fitting tribute to the retiring Senate Pro Tempore and the distinguished Chairman of the Senate Appropriations Committee.

This section was strongly endorsed by the White House and NASA, and on May 20, 1988, the National Space Technology Laboratories was officially renamed the John C. Stennis Space Center by Executive Order.

Authorization for NASA to Obtain Nuclear Fuel from the Department of Energy for Planetary Missions—Section 11

This section provides authority to NASA to obtain nuclear fuel from DOE, on terms and at costs, as may be agreed upon between the NASA Administrator and the Secretary of DOE, for outer solar system exploration (i.e., beyond two astronomical units).

NASA missions to the outer solar system (i.e., beyond two astronomical units) use radioisotope thermoelectric generators (RTGs) because they provide the necessary power for less mass than batteries, fuel cells, solar arrays, or other alternatives at the solar intensities at those distances. The United States has unquestioned preeminence in outer solar system exploration, and NASA has planned a series of missions which will maintain this Nation's leadership position. These missions include, among other things, the Comet Rendezvous-Asteroid Flyby (CRAF), Cassini, and the Saturn Orbiter/Saturn Probe, all of which will require RTGs.

DOE plans, however, to institute a policy of full cost recovery for future production of RTGs. By interagency agrreement, NASA currently receives fuel at approximately half price. This new policy will represent a cost impact of $70–100 million to the CRAF and Cassini projects alone.

The Committee is currently exploring this issue with the Senate Committee on Energy and Natural Resources and hopes to further amend this section before consideration by the Senate to allow acquisition "at less than full cost."

International Space Rescue Initiative—Section 12

The Committee and the World acknowledged the tragedy of our astronaut loss in the Challenger disaster. And the Committee and the World hope that such a tragedy will never again occur. However, space exploration is a risky business, and the Committee realizes that precautions must be taken to reduce the risks of space. Since the Challenger tragedy, NASA has gone to great length, following the Rogers Commission report, to secure crew egress in the case of an aborted space shuttle launch and landing. However, what if the mishap occurred in space? Are the United States and the other spacefaring nations of the world able to rescue a stranded astronaut?

Current international law, to which the United States is a cosignator, provides for human rescue at sea. SOLAS, the International Convention for the Safety of Life at Sea, spells out in minute detail, the provisions for human rescue regardless of national registry or cargo. Such a regime and capability also should exist for the rescue of humans in space. But at present it does not.

The "Return of Astronauts and the Return of Objects Launched into Outer Space" International Space Agreement of 1968 sets precedent for addressing human space rescue. But it lacks specific detail or an implementation plan. It is clear, therefore, that some additional steps are required if space rescues are to be feasible.

One possible mechanism for pursuing such an opportunity is the April, 1987 Agreement between the United States and the Union of Soviet Socialist Republics concerning cooperation in the "Exploration and Use of Outer Space for Peaceful Purposes." Expansion of this agreement could provide an opportunity for the United States and Soviet Union to enlist the support of other nations to move forward immediately with a working group to explore the possibility of space rescue. The group would be required to consider the compatibility of life support systems, space suits, docking and communication systems and the ability to respond in a timely manner in case of a mishap. An earlier initiative by the White House for a simulated rescue mission using the U.S. space shuttle and the Soviet Union's space station was rejected by the Soviet Union. However, the situation today is dramatically different—both with the Soviet Union and our spacefaring allies—and the timing appears to be right for creating an international space rescue working group.

In addition to the pressing reality of saving human life, this proposal relates to decisions involving billions of dollars. NASA is currently considering development of a new space suit (EMU), a space station crew emergency rescue vehicle, communications upgrading, among others. As NASA considers these issues, it should at least consider the compatibility of these systems with those of other spacefaring nations as was done in the report on international spacecraft and docking systems that was just submitted to the Committee.

The Committee expects NASA to take the initiative immediately to start the interagency process of creating a working group to deal with this issue. The Committee is very eager to work with NASA and the other agencies involved and feels it is time to move forward.

Office of Commercial Space Transportation—Section 13

The Committee has authorized $3,827,000 for the operations of the Office of Commercial Space Transportation (OCST) within the DOT. This conforms to the President's request and will enable OCST to meet projected demand in FY 1989 from entities seeking a DOT license to launch commercial expendable launch vehicles.

OCST was established pursuant to P.L. 98-575, with the specific purpose of establishing and enforcing the licensing and regulatory regime necessary for commercial space transportation operations. These activities include safety research and planning, licensing procedures.

The Committee's authorization represents an increase of more than $2 million over the FY 1988 appropriated amounts. The Committee concurs in the need for these increases due to projected commercial launch operations beginning in FY 1989. The Office currently has under review and in process six commercial launch applications. The Office anticipates that 10 more requests for licensing actions will be received before the end of the calendar year. This is a 250 percent increase over 1987, so clearly additional personnel will be required if the Office is to perform its statutory duties.

The Committee is concerned over the trend in appropriations for OCST, which have averaged only 50 percent of the President's request. The Committee feels that this situation is aggravated by the location of OCST in the Office of the Secretary of Transportation, where it competes for resources against other activities of that office.

The Committee strongly believes that the current placement of the OCST budget within the Office of the Secretary of Transportation's budget request is detrimental to the efficient operations of that office, and to the Congressional funding process. The Committee, therefore, directs DOT and OMB to consider a separate line item for OCST in the FY 1990 budget submission.

The primary focus of OCST is to ensure that each commercial launch licensed by the Office has undergone thorough and rigorous safety analyses. This process is, by definition, complex and time-consuming and involves much more than simple processing of license applications. For example, in FY 1988, OCST produced a document entitled *Hazard Analysis of Commercial Space Transportation*. This analysis will serve as a basis for assessing risks associated with launches of commercial vehicles, as well as for imposing minimum insurance requirements on vehicle operators. This document required knowledge and analyses in many complex areas such as hazardous materials transportation, and risk assessment and management.

The Committee believes that as long as a commercial expendable launch industry exists, there must be adequate resources to properly oversee and regulate that industry. This is essential to ensure that the United States can fulfill its obligations under international treaties, as well as to protect fully the health and safety of the public.

The Committee has chosen not to incorporate the President's proposal for expendable launch vehicle liability reforms in the authorization bill. This proposal was included in the budget submission for OCST. The Committee has initiated hearings in this area, and has commissioned a study by the Congressional Research Service to examine the world space insurance markets. These actions will provide a basis on which to decide whether further action is necessary in this area.

ESTIMATED COSTS

In accordance with paragraph 11(a) of rule XXVI of the Standing Rules of the Senate and section 403 of the Congressional Budget Act of 1974, the Committee provides the following cost estimate, prepared by the Congressional Budget Office:

U.S. CONGRESS,
CONGRESSIONAL BUDGET OFFICE,
Washington, DC, May 26, 1988.

Hon. ERNEST F. HOLLINGS,
Chairman, Committee on Commerce, Science and Transportation, U.S. Senate, Washington, DC.

DEAR MR. CHAIRMAN: The Congressional Budget Office has prepared the attached cost estimate for S. 2209, the National Aeronautics and Space Administration Authorization Act, 1989.

If you wish further details on this estimate, we will be pleased to provide them.

Sincerely,

James L. Blum,
Acting Director.

CONGRESSIONAL BUDGET OFFICE COST ESTIMATE

1. Bill number: S. 2209.

2. Bill title: The National Aeronautics and Space Administration Authorization Act, 1989.

3. Bill status: As ordered reported by the Senate Committee on Commerce, Science, and Transportation, May 24, 1988.

4. Bill purpose: S. 2209 would authorize appropriations to the National Aeronautics and Space Administration (NASA) and the Office of Commercial Space Transportation (OCST) in the Department of Transportation for fiscal year 1989.

5. Estimated cost to the Federal Government:

[By fiscal year, in millions of dollars]

	1989	1990	1991	1992	1993
NASA:					
Authorization Level	11,105				
Estimated Outlays	6,667	3,629	624	169	16
OCST:					
Authorization Level	4				
Estimated Outlays	3	1			
Total:					
Authorization Level	11,108				
Estimated Outlays	6,670	3,630	624	169	16

The costs of this bill are in budget functions 250 and 400. Including outlays from prior year appropriations, the total outlays for NASA would be $10.4 billion in 1989, assuming appropriation of the authorized amount.

Basis of estimate: This estimate assumes that the full amounts authorized would be appropriated for each fiscal year. Detailed information is shown in the table below. The estimated outlays are based on historical spending patterns.

ESTIMATED COST OF S. 2209

[By fiscal year, in millions of dollars]

	1989	1990	1991	1992	1993
Research and Development:					
Authorization Level	4,278				
Estimated Outlays	2,083	1,613	436	145	
Space Flight, Control, and Data Communications:					
Authorization Level	4,686				
Estimated Outlays	2,976	1,579	131		
Construction of Facilities:					
Authorization Level	260				
Estimated Outlays	17	148	56	23	16
Research and Program Management:					
Authorization Level	1,880				

ESTIMATED COST OF S. 2209—Continued

[By fiscal year, in millions of dollars]

	1989	1990	1991	1992	1993
Estimated Outlays	1,590	290			
Subtotal, NASA:					
Authorization Level	11,105				
Estimated Outlays	6,667	3,629	624	169	16
Office of Commercial Space Transportation:					
Authorization Level	4				
Estimated Outlays	3	1			
Total, S. 2209:					
Authorization Level	11,108				
Estimated Outlays	6,670	3,630	624	169	16

6. Estimated cost to State and local governments: None.

7. Estimate comparison: None.

8. Previous CBO estimate: On May 19, 1988, CBO prepared an estimate for H.R. 4561, the Multiyear National Aeronautics and Space Administration Authorization Act, as ordered reported by the House Committee on Science, Space, and Technology, May 12, 1988. H.R. 4561 would authorize appropriations to NASA and the OCST for fiscal years 1989 through 1991, including $11,492 million for 1989, $14,392 million for 1990, and $15,750 million for 1991.

9. Estimate prepared by: Michael Sieverts.

10. Estimate approved by: James L. Blum, Assistant Director for Budget Analysis.

REGULATORY IMPACT STATEMENT

In accordance with paragraph 11(b) of rule XXVI of the Standing Rules of the Senate, the Committee provides the following evaluation of the regulatory impact of the legislation.

Primarily, this bill authorizes the appropriation of funds for the conduct of space and aeronautical research and development activities to carry out the policy and purpose of the National Aeronautics and Space Act of 1958. These activities are conducted in NASA laboratories, by NASA personnel and through contracts with industry, universities, and research institutions for research and development and for supporting scientific and technical services. The Committee has concluded that the nature of these activities is such that there is no regulatory effect on individuals and businesses and no effect on individual privacy.

The bill also authorizes the appropriation of funds for OCST at DOT. This office licenses and regulates the commercial expendable launch vehicle industry in order to protect the public health and safety and comply with existing U.S. treaty and international law obligations. This office was created to reduce the regulatory burden and paperwork requirements on the industry, and the Committee's action represents the reauthorization of an existing program.

Thus, OCST and NASA programs have no effect on individual privacy and should not have an unacceptable regulatory effect on the individuals or businesses who choose to participate.

Neither of the above mentioned programs would have an inflationary impact or any additional paperwork requirements.

SECTION-BY-SECTION ANALYSIS

SECTION 1

The short title of this bill is the "National Aeronautics and Space Administration Authorization Act, 1989.".

SECTION 2

This section authorizes $11,104,500,000 for NASA in FY 1989.

These monies are distributed to four appropriations accounts:

1. *Research and Development.*—$4,278,200,000 for space station, space science and applications, space transporation capability development, commercial programs, aeronautical research and technology, transatmospheric research and technology, and space research and technology.

The major assumptions in this area are funding of $867,400,000 and a strong endorsement for the space station in FY 1988, restoration of funding for the Advanced Communications Technology Satellite program, initiation of a new space technology initiative—Pathfinder—but at a reduced level of funding, approval of a "new start" for the Advanced X-Ray Astrophysics Facility, and funding of the Space Grant College and Fellowship Program.

2. *Space Flight, Control and Data Communications.*—$4,686,200,000 for space shuttle production and operations capability, space transportation operations, space tracking and data acquisition, and expendable launch vehicle (ELV) operations.

The major assumptions in this account are deferral of funding for the structural spares program for a fifth orbiter, endorsement of a new start for the advanced solid rocket motor program, augmentation of the current ELV procurement program at NASA, and full support of the space shuttle operations budget request and anomaly resolution activities to facilitate the return of a safe, reliable shuttle to flight status.

3. *Construction of Facilities.*—$260,100,000 for a variety of repair, rehabilitation, and new construction activities required for a robust civilian space program.

The major assumptions in this account are that some space station facilities can be delayed because of program delays and that the repair of certain wind tunnel facilities at the NASA Ames, Lewis, and Langley Research Centers is of the highest priority. These tunnels are critical to both civil and military aircraft development.

4. *Research and Program Management.*—$1,880 million for all civil service staff, maintenance of facilities and support of research and development programs and contract activities, and technical and administrative support of research and development programs.

The major assumption in this account is that NASA will increase the civil service employee base by 525 new slots, primarily for space transportation activities.

SECTIONS 3, 4, AND 5

These sections establish strict parameters for the Administrator of NASA concerning the amount of flexibility he or she has with construction of facilities activities, the transfer of funds from one account to another, and the use of funds for activities not approved by the Committee. These provisions are included in the NASA Authorization bill each and every year.

SECTION 6

This section instructs NASA to distribute its research and development funds on a geographical basis where possible. The Committee annually legislates this requirement and believe it is in the national interest.

SECTION 7

This section gives NASA the authority to permit the funds provided in section 2(b)(1) of this bill for the construction of a Government-owned, company-operated advanced solid rocket motor facility to be used for a company-owned, company-operated facility if NASA determines that the latter is in the national interest and is in the best interest of a safe, reliable space shuttle program. At present, the proposed request for proposal for the advanced solid rocket motor program requires all contractors to bid for (1) a Government-owned, company-operated facility and (2) a privately financed facility, both of which would be on a tentative Government site. Bidders also would have a third option of proposing a privately financed facility at the site of the offerer's choice.

NASA lacks the legal authority to enter into a contractual agreement for option 2 (privately-financed facility at Government site) or Option 3 (privately-financed facility at site chosen by offerer. This section gives NASA that authority.

SECTION 8

Presently, subsection 304(e) of the National Aeronautics and Space Act of 1958 provides the authority for certain NASA personnel, as well as certain employees of contractors and subcontractors, to carry firearms in the fulfillment of their official duties.

This amendment to section 304 of the NASA Space Act, specifically a new subsection (f), would provide the authority to arrest without warrant to NASA employees designated by the Administrator as well as those contractor and subcontractor personnel carrying out their official duties while guarding and protecting property of the United States under the administration and control of NASA or its contractors or subcontractors.

Subsection (e) and new subsection (f) when read together would allow certain NASA personnel as well as certain subcontractor and contractor personnel to make an arrest for the violation of Federal and, in some instances, State laws occurring on NASA property or involving property owned by or in the custody of NASA if the person has reason to believe that the person to be arrested has committed or is committing a felony. Security personnel shall use the minimum degree of force, including firearms, necessary to effectuate the arrest.

NASA shall develop regulations to be approved by the Administrator and the Attorney General before this authority is exercised.

The authority is consistent with that granted to DOE pursuant to 42 U.S.C. 2201(k).

SECTION 9

This section requires that the National Space Technology Laboratories of NASA, located in Bay St. Louis, MS, is named and designated "John C. Stennis Space Center."

This is a just and fitting tribute to the retiring Senate Pro Tempore and the distinguished Chairman of the Senate Appropriations Committee. This tribute is strongly endorsed by NASA and the White House.

SECTION 10

This section reiterates the Committee position that the space station may be used only for peaceful purposes. This language is consistent with existing U.S. treaty obligations (the Outer Space Treaty) and current law—P.L. 99-170. This language permits DOD research and development activities on the space station.

SECTION 11

This section gives the Administrator of NASA the authority to obtain nuclear fuel from DOE for outer solar system exploration on terms and at costs that may be agreed upon.

SECTION 12

This section expresses the Sense of the Senate that the President should establish a multilateral Space Rescue and Space Assistance Working Group to explore the creation of an international space rescue regime and the development of compatible docking, communications, and life support systems to support the effectiveness of this regime.

Such a regime would permit all spacefaring nations to reiterate their commitments to the 1968 Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Objects Launched into Outer Space and would extend to incidents of distress in space the principles of rescue universally accepted with respect to incidents of distress at sea and in the air.

SECTION 13

This section authorizes $3,827,000 for FY 1989 for OCSP in DOT. This Office oversees the regulation and licensing of commercial ELV activities and was established by this Committee pursuant to P.L. 98-575—the Commercial Space Launch Act. The level authorized is the administration's request.

CHANGES IN EXISTING LAW

In compliance with paragraph 12 of rule XXVI of the Standing Rules of the Senate, changes in existing law made by the bill, as reported, are shown as follows (existing law proposed to be omitted is enclosed in black brackets, new material is printed in italic, existing law in which no change is proposed is shown in roman):

THE NATIONAL AERONAUTICS AND SPACE ACT OF 1958

Section 304 of that Act

SECURITY

SEC. 304. (a) * * *

(b) through (e) * * *

(f) Under regulations to be prescribed by the Administrator and approved by the Attorney General of the United States, those officers and employees of the Administration and of its contractors and subcontractors authorized pursuant to subsection (e) to carry firearms may arrest a person without warrant for any offense against the United States committed in their presence, or for any felony cognizable under the laws of the United States if they have reasonable grounds to believe that such person has committed or is committing such felony. Individuals granted authority to make arrests by this subsection may exercise that authority only while guarding and protecting property of the United States under the administration and control of the Administration or one of its contractors or subcontractors.

THE COMMERCIAL SPACE LAUNCH ACT

Section 24 of that Act

AUTHORIZED APPROPRIATIONS

SEC. 24. There are authorized to be appropriated to the Secretary $4,000,000 for fiscal year 1985. There is authorized to be appropriated to the Secretary to carry out this Act $586,000 for fiscal year 1986. There is authorized to be appropriated to the Secretary to carry out this Act $4,548,000 for fiscal year 1988. *There is authorized to be appropriated to the Secretary to carry out this Act $3,827,000 for fiscal year 1989.*

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